JRS Dynamic Rollover Test

2010 Ford F-150 Supercab

Sponsored By:

Automotive Safety Research Institute
Charlottesville, VA.

Vehicle Loaned by:
State Farm Insurance Company
Chicago, IL.

Introduction

The Center for Injury Research conducted a JRS dynamic rollover test consisting of two rolls of a 2010 Ford F-150 on April 11th and 12th. This test report is organized in sections containing test information, data tables and photographs as follows:

Section 1 – Test Procedures and Summaries

Section 2 – Test Results, Data Tables and Selected Comparison Photographs for Roll 1.

Section 3 – Test Results, Data Tables and Selected Comparison Photographs for Roll 2.

Section 4 – Data Graphs

Section 5 – All Test Photographs

Enclosed with this report is a DVD of the video of both rolls.

2010 Ford F-150

Executive Summary

The test was a two roll event. The planned difference between the rolls was the pitch of the vehicle; 5 degrees in Roll 1 and 10 degrees in Roll 2 and the position of the Hybrid III dummy. For Roll 1, the dummy was located “out of position;" leaning towards the passenger side approximately 45° in order to simulate approximately 1g of lateral acceleration. For Roll 2, the dummy was left in the resting position from the previous roll. The rear window (backlight) was broken upon arrival so the glass was replaced by a local glass vendor. The length of the vehicle bed extended beyond the width of the JRS towers, approximately 21 inches of the rear bed was removed. Table 1 describes the impact conditions of each test. Table 2 shows the injury assessment reference values for the low durometer neck that was used.

Table 1 Summary of Test Conditions

Roll	Pitch	Road Speed	Contact Angle	Roll Rate	Yaw
1	5.7 deg	14.8 mph	150 deg	194 deg/sec	10 deg
2	10 deg	14.9 mph	145 deg	195 deg/sec	10 deg

Table 2 Lower Neck IARV's for 10% Probability of an AIS ≥ 3 Injury

Neck Type	My (Nm) Flexion	My (Nm) Extension	Mx (Nm)	Axial Fz (N)
Production	380	−156	268	4000
Low Durometer	90-110	−38-−46	59-90	1640-2000
Human/Cadaver	58			1500

In Roll 1, the peak lower neck compressive load was 690 N and the peak lower neck moment was 22 Nm in flexion and 31 Nm in extension. The peak intrusion speed at the top of the A-Pillar was 6.0 mph with a peak crush of 6.7 inches.

In Roll 2, the peak lower neck compressive load was 1,751 N and the peak lower neck moment was 169 Nm in flexion and 34 Nm in extension. The peak intrusion speed at the top of the A-Pillar was 11.1 mph with a peak crush of 5.2 inches.

1. Test Procedure and Summaries

For each roll of the test, the following steps are performed as necessary:

1. Inspect the test vehicle for prior damage, rust or other factors that might influence the outcome of the test
2. Prepare the test equipment
3. Install and prepare the instrumentation and video cameras
4. Install the test vehicle in test fixture
5. Perform pre-test measurements
6. Photograph the vehicle
7. Conduct the impact test
8. Perform post test measurements
9. Photograph the vehicle following the test

The set up of the test vehicle in the fixture and the instrumentation in the vehicle was the same for Rolls 1 and 2 with the exception of the pitch angle; Roll 1 = 5.0° and Roll 2 = 10.0°.

The test weight of the vehicle was 4995 pounds. The initial weight of the vehicle was 5066 pounds. The test roll moment of inertia was approximately 853.79 lb-ft-sec^2 for a referenced value of 883.04 lb-ft-sec^2.

The vehicle was suspended on mounts at the rear and at the front in a manner that allowed it to roll freely and be dropped, passenger side (near side) leading.

Three string potentiometer mounts were placed approximately on the longitudinal roll axis of the vehicle at the cg of the vehicle. The sensors measured the roof dynamics at the top of the driver's side A-pillar, at the header inboard of the A-pillar and at the top of the passenger's side A-pillar. An instrumented, restrained Hybrid III 50th percentile male test dummy was placed in the driver's seat. The dummy was instrumented with upper and lower neck load cells as well as a triaxial head accelerometer. In addition, seat belt load cells were utilized at the lap and shoulder belt.

The Hybrid III dummy was equipped with a more biofidelic (low durometer) neck, located in the driver's seat which was positioned in the mid seat position. The dummy was restrained using the vehicle's standard 3 point harness. The vehicle also had a side curtain airbag and a belt pretensioner which were fired at 30 degrees of roll during the first impact test. The dummy's head was chalked before each roll to locate impact marks during the tests. The lower neck mounting block was replaced with a block that increased the neck angle forward 30 degrees from the nominal position.

For the first roll the dummy was tethered "out of position" with a small cable that electronically disconnected at approximately 30° of roll. The "out of position" location of the dummy was found by rotating the vehicle by 90° toward the passenger side. This orientation simulated the dummy accelerating toward the passenger side door at 1 g. For the second roll the dummy was left in the same position from the end of the first roll, held in place by the belt in tension.

Six vertical and two lateral load cells were placed in the moving roadway to record the impact characteristics of the test.

Two string potentiometers were placed on the fixture support towers to record vehicle vertical motion characteristics during the test. One string potentiometer was located in the front drop tower and the other was located in the rear drop tower. The rear string potentiometer did not register data in this test and the vehicle pitch was calculated using high speed camera data.

A roll encoder was placed on the cable pulley which pulls the moving roadway to record the roadway velocity throughout the test. In addition, a roll rate sensor was placed inside the vehicle.

The equipment used in the conduct of this test is listed in Table 3 and the test vehicle identification data is shown in Table 4 below.

Table 3 Equipment and Instrumentation

Item	MFR./Model
String Potentiometer – Driver's Side A-Pillar	Space Age Control – 301432
String Potentiometer – Roof Header	Space Age Control – 301432
String Potentiometer – Passenger's Side A-Pillar	Space Age Control – 301432
String Potentiometer – Front Fixture Support Tower	Space Age Control – 4332-01
String Potentiometer – Rear Fixture Support Tower	Space Age Control – 4332-01
Upper Neck Load Cell	RA Denton 1716A
Lower Neck Load Cell	RA Denton 1794A
Triaxial Head Accelerometer	Endevco, 7264C-2KTZ-2-240
Belt Load Cell - Lap	RADenton 3255
Belt Load Cell - Torso	RADenton 3255
Roll Rate Sensor	DTS ARS
Hybrid III, 50th Percentile Male	Denton 50th Male
Vertical Load Cell 1	Transducer Techniques, SWP-20k – 173372
Vertical Load Cell 2	Transducer Techniques, SWP-20k – 176138
Vertical Load Cell 3	Transducer Techniques, SWP-20k – 176139
Vertical Load Cell 4	Transducer Techniques, SWP-20k – 176140
Vertical Load Cell 5	Transducer Techniques, SWP-20k – 176141
Vertical Load Cell 6	Transducer Techniques, SWP-20k – 176142
Lateral Load Cell 1	Transducer Techniques, DSM-8k – 149806
Lateral Load Cell 2	Transducer Techniques, DSM-8k – 149807
Roadway Velocity Roll Encoder	Contelec – RSC 2201 236 111 106
Vehicle Data Acquisition System	Diversified Technical Systems, TDAS PRO SIM
Roadway Data Acquisition System	Diversified Technical Systems, TDAS PRO SIM
JRS Fixture Acquisition System	Measurement Computing, USB – 1608FS

Table 4 General Test Vehicle Data Test Vehicle: 201 Ford F-150 Supercab

Test Vehicle Information:	
Manufacturer: Ford	VIN: 1FTEX1C8XAFA29500
Gross Weight: 7000 lb	Curb Weight: 5082 lb
Sunroof: No	2WD/4WD: 2WD
Equivalent Years: 2009- Present	Body Type: 4 Door Pickup

2. Test Results, Data Tables and Selected Comparison Photographs for Roll 1.

The results of the first roll of the JRS Dynamic Rollover Test are presented in this section. In the roll, the vehicle dropped as planned and contacted the vehicle's roof structure.

Roll 1 – 04/11/12

Summary of Results

Instrument	Peak Value	Residual Intrusion (inches)	Peak Velocity (mph)
Sum of Vertical Load Cells (near side contact)	6117 lb		
Sum of Vertical Load Cells (far side contact)	22,106 lb		
Sum of Lateral Load Cells (near side contact)	500 lb		
Sum of Lateral Load Cells (far side contact)	789 lb		
Driver's Side A-Pillar String Potentiometer	-6.7 in	-4.6 in	-6.0
Roof Header String Potentiometer	-5.3 in	-3.4 in	-5.4
Passenger's Side A-Pillar String Potentiometer	-1.1 in	-0.5 in	-2.1

Instrument	Maximum Value	Minimum Value
Lap Belt Load	246 lbs	-12 lbs
Shoulder Belt Load	597 lbs	-6 lbs
Dummy Head Acceleration Ax	17 G's	-23 G's
Dummy Head Acceleration Ay	10 G's	-25 G's
Dummy Head Acceleration Az	58 G's	-6 G's
Lower Neck Load Cell Fx	504 N	-1,051 N
Lower Neck Load Cell Fy	459 N	-96 N
Lower Neck Load Cell Fz	1,282 N	-690 N
Lower Neck Load Cell Mx	15 N-m	-36 N-m
Lower Neck Load Cell My	22 N-m	-31 N-m
Upper Neck Load Cell Fz	1,617 N	-1,080 N
HIC	46.2	

The vertical load cells mounted on the roadway platform show the near and far side impacts. For the first roll, the vehicle struck the roadway on the near side at approximately 1.76 seconds. The entire roll sequence was completed by approximately 2.25 seconds.

The string potentiometers located on the fixture support towers show the vertical vehicle motion throughout the test. The front of the vehicle dropped 4.89 inches and the rear dropped 2.17 inches prior to initial touchdown. The vehicle was pitched at 5.7 degrees at contact.

The roll encoder located on the cable pulley shows the roadway velocity throughout the roll. During the first roll, the roadway was traveling at 14.8 mph at contact. A roll rate sensor in the vehicle was used to determine the roll angle and roll rate at impact. The roll angle of the vehicle was 150 degrees and the roll rate was 194 degrees per second at the roadway impact.

There was moderate to high deformation beginning at the A-Pillar that traveled longitudinally down the vehicle nearly to the rear webbing. The driver side window shattered and there was significant damage to the windshield.

The driver side doors were not opened after the first roll. The passenger side doors opened normally.

The side window-curtain airbag was removed after the first roll.

Roll 1 Comparison Photographs

Figure 1: Vehicle Pre Roll 1

Figure 2: Vehicle Post Roll 1

3. Test Results, Data Tables and Selected Comparison Photographs for Roll 2.

The results of the second roll of the JRS Dynamic Rollover Test are presented in this section. In the roll, the vehicle dropped as planned and contacted the moving roadbed.

Roll 2 – 04/12/12

Summary of Results

Instrument	Peak Value	Residual Intrusion (inches)	Peak Velocity (mph)
Sum of Vertical Load Cells (near side contact)	9,615 lb		
Sum of Vertical Load Cells (far side contact)	27,607 lb		
Sum of Lateral Load Cells (near side contact)	525 lb		
Sum of Lateral Load Cells (far side contact)	986 lb		
Driver's Side A-Pillar String Potentiometer	-5.2 in	-2.6	-11.1
Roof Header String Potentiometer	-4.6 in	-2.2	-8.1
Passenger's Side A-Pillar String Potentiometer	-1.1 in	-0.3	-1.5

Instrument	Maximum Value	Minimum Value
Lap Belt Load	260 lbs	-38 lbs
Shoulder Belt Load	152 lbs	-2 lbs
Dummy Head Acceleration Ax	11 G's	-15 G's
Dummy Head Acceleration Ay	7 G's	-38 G's
Dummy Head Acceleration Az	15 G's	-17 G's
Lower Neck Load Cell Fx	417 N	-337 N
Lower Neck Load Cell Fy	875 N	-91 N
Lower Neck Load Cell Fz	291 N	-1,751 N
Lower Neck Load Cell Mx	9 N-m	-115 N-m
Lower Neck Load Cell My	169 N-m	-34 N-m
Upper Neck Load Cell Fx	77 N	-219 N
Upper Neck Load Cell Fy	34 N	-433 N
Upper Neck Load Cell Fz	499 N	-621 N
Upper Neck Load Cell Mx	1 N-m	-19 N-m
Upper Neck Load Cell My	10 N-m	-10 N-m

Chest Deflection	0.7 N	-0.7 N
Chest Acceleration Ax	11.2 G's	-2.7 G's
Chest Acceleration Ay	4.3 G's	-3.2 G's
Chest Acceleration Az	15.8 G's	-2.7 G's
Pelvis Acceleration Az	19.2 G's	-20.8 G's
HIC	36	

The vertical load cells mounted on the roadway platform show the near and far side impacts. The vehicle struck the roadway on the near side at approximately 1.74 seconds. The entire roll sequence was completed by approximately 2.25 seconds.

The string potentiometers located on the fixture support towers show the vertical vehicle motion throughout the test. The front of the vehicle dropped 4.54 inches and the rear did not function during the test. The vehicle was estimated to be at approximately 10 degrees of pitch from the high speed camera data.

The roll encoder located on the cable pulley shows the roadway velocity throughout the roll. During the second roll, the roadway was traveling at 14.9 mph at contact. A roll rate sensor in the vehicle was used to determine the roll angle and roll rate at impact. The roll angle of the vehicle was 145 degrees and the roll rate was 195 degrees per second at the roadway impact.

During the second roll the roof header buckled and tented upward. The windshield suffered heavy damage but was held in place by the lamination.

The doors were not opened on the driver side of the vehicle.

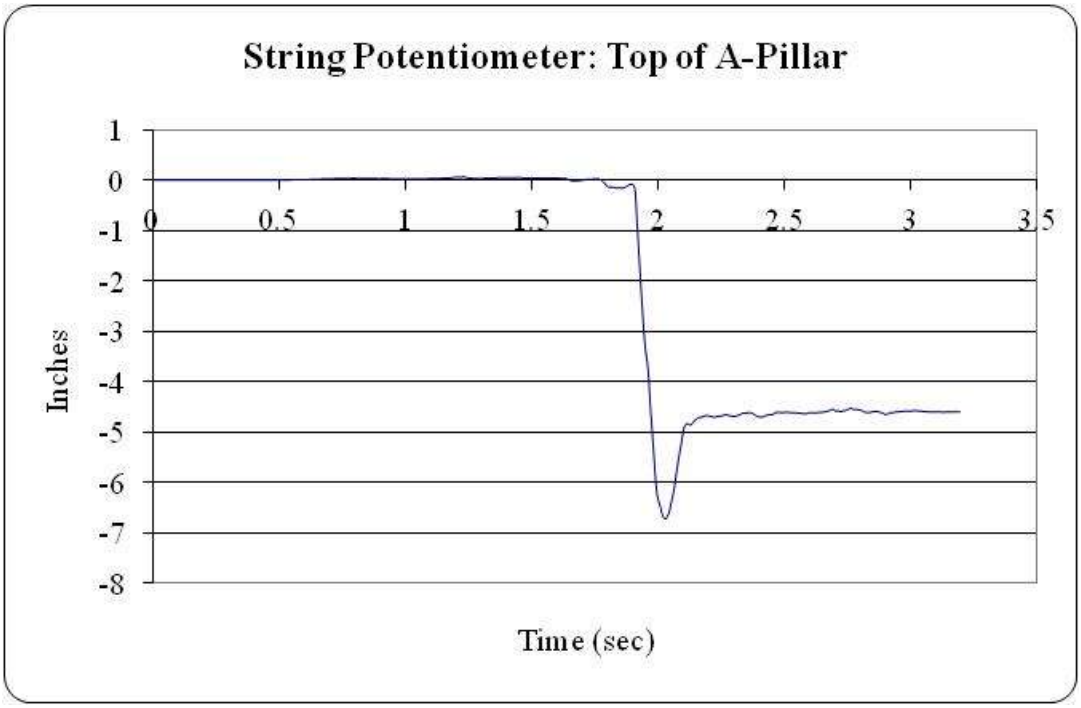
Roll 2 Comparison Photographs

Figure 3: Vehicle Pre Roll 2

Figure 4: Vehicle Post Roll 2

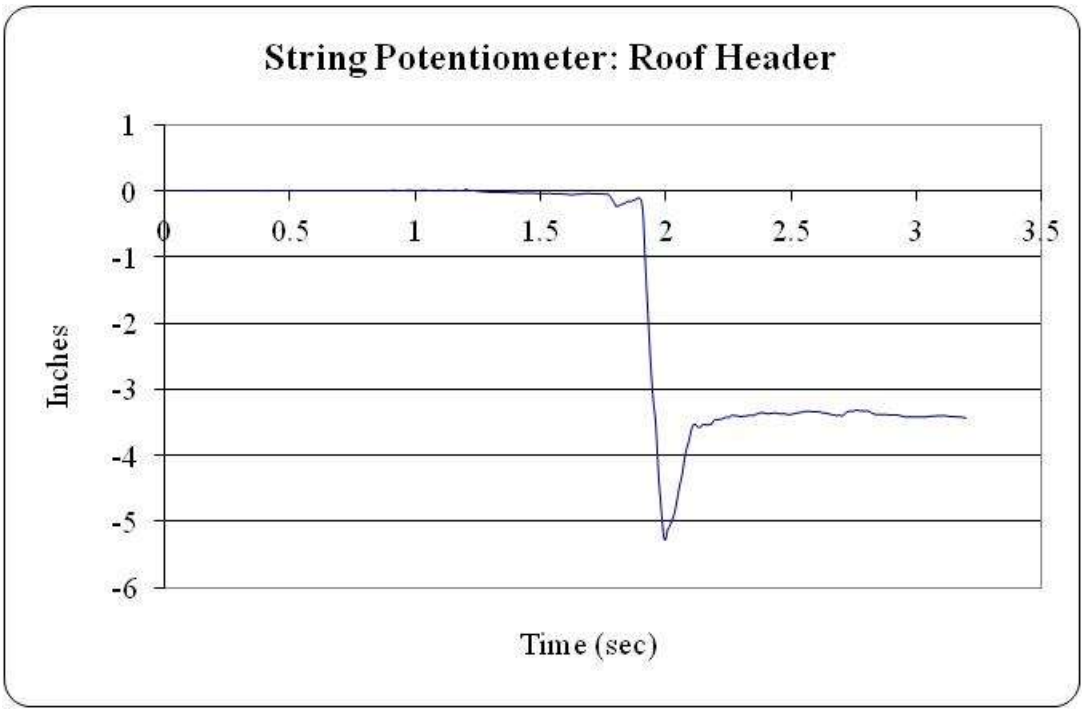
4. Data Graphs

Roll 1 Data Plots – 04/11/12



Plot 1: Top of Driver's Side A-Pillar Displacement v. Time

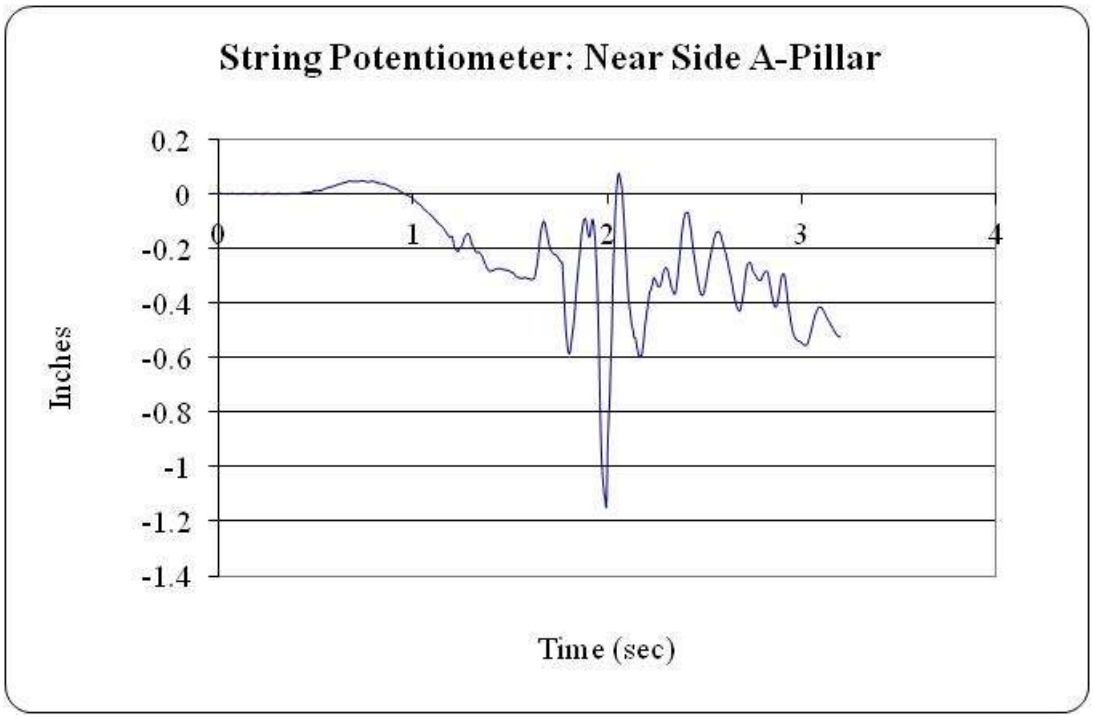
Data Sampling Rate: 10 kHz



Plot 2: String Potentiometer Driver's Side Roof Header Displacement v. Time

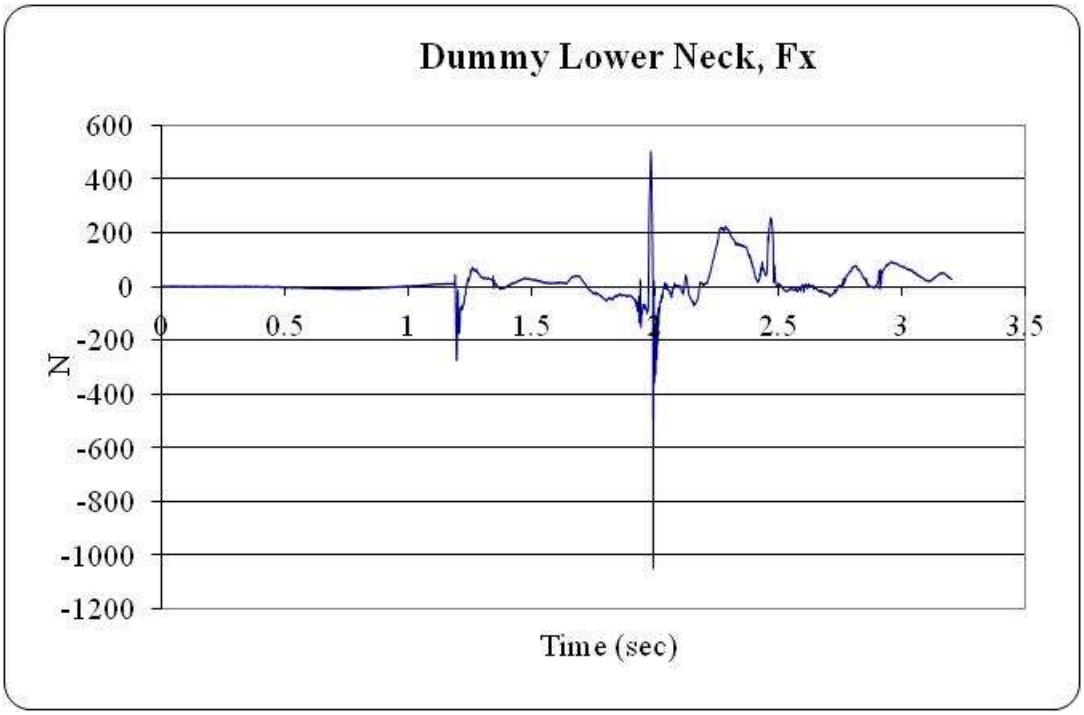
Data Sampling Rate: 10 kHz

Roll 1



Plot 3: String Potentiometer Passenger's Side A-Pillar Displacement v. Time

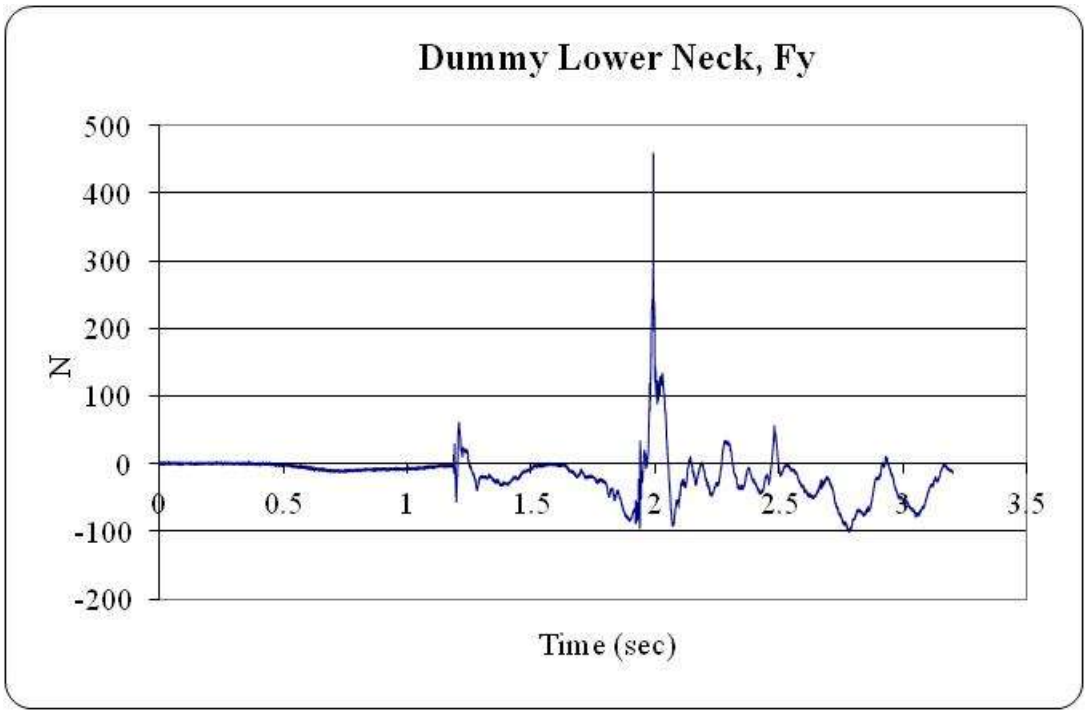
Data Sampling Rate: 10 kHz



Plot 4: Lower Neck Load, Fx, v. Time

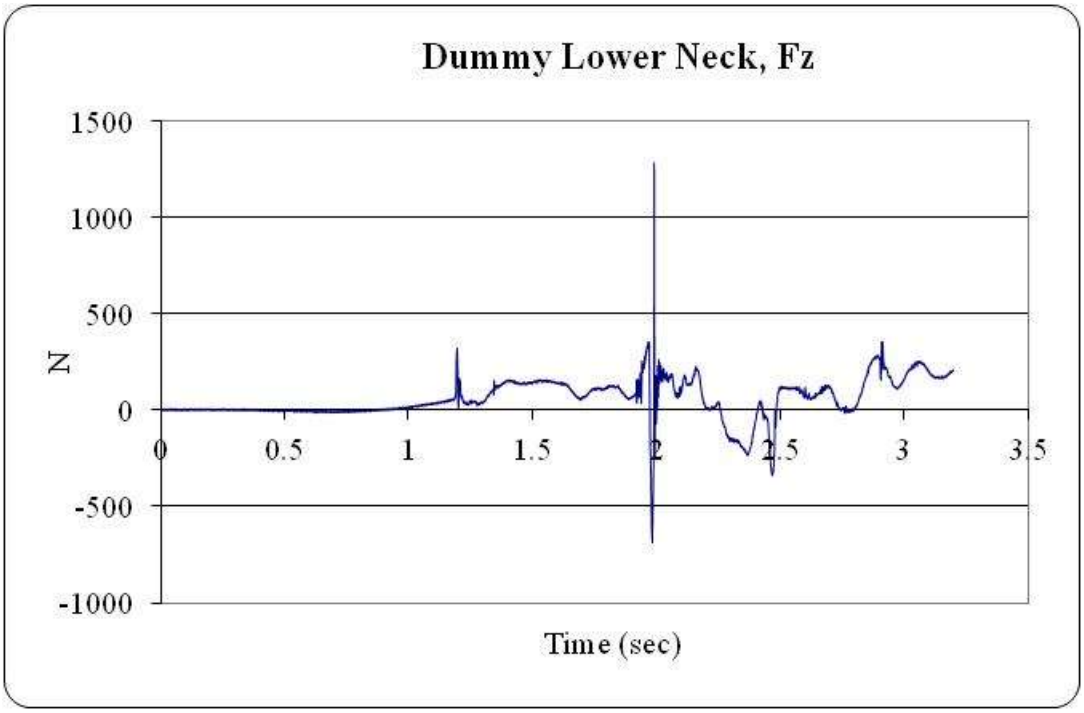
Data Sampling Rate: 10 kHz

Roll 1



Plot 5: Lower Neck Load, Fy, v. Time

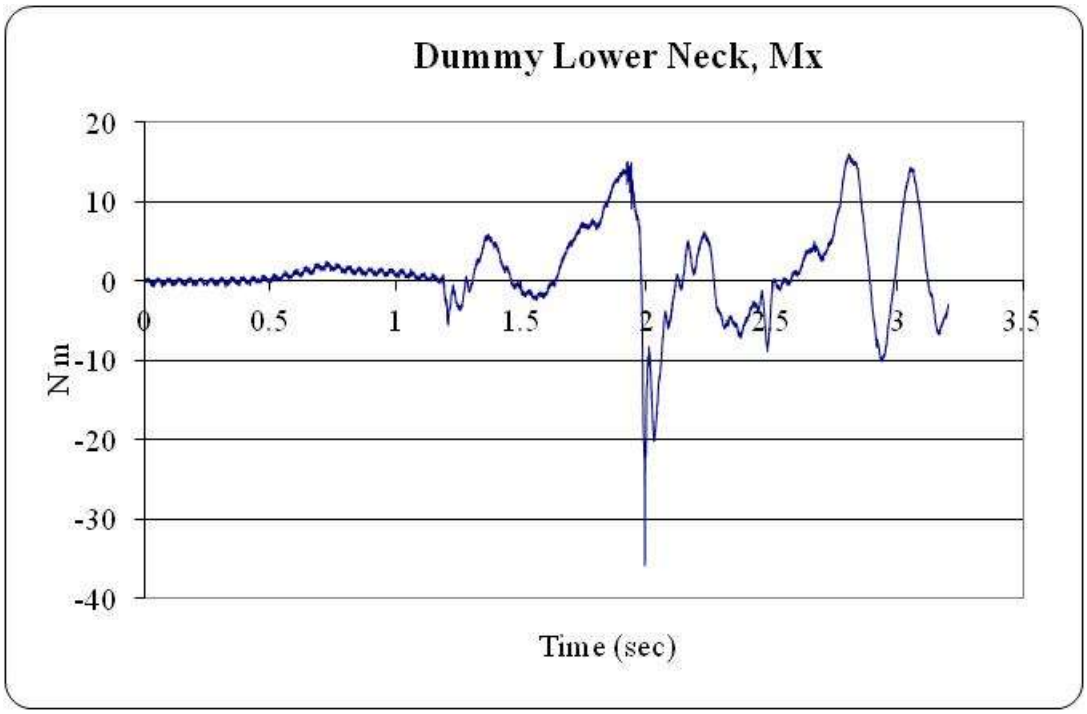
Data Sampling Rate: 10 kHz



Plot 6: Lower Neck Load, Fz, v. Time

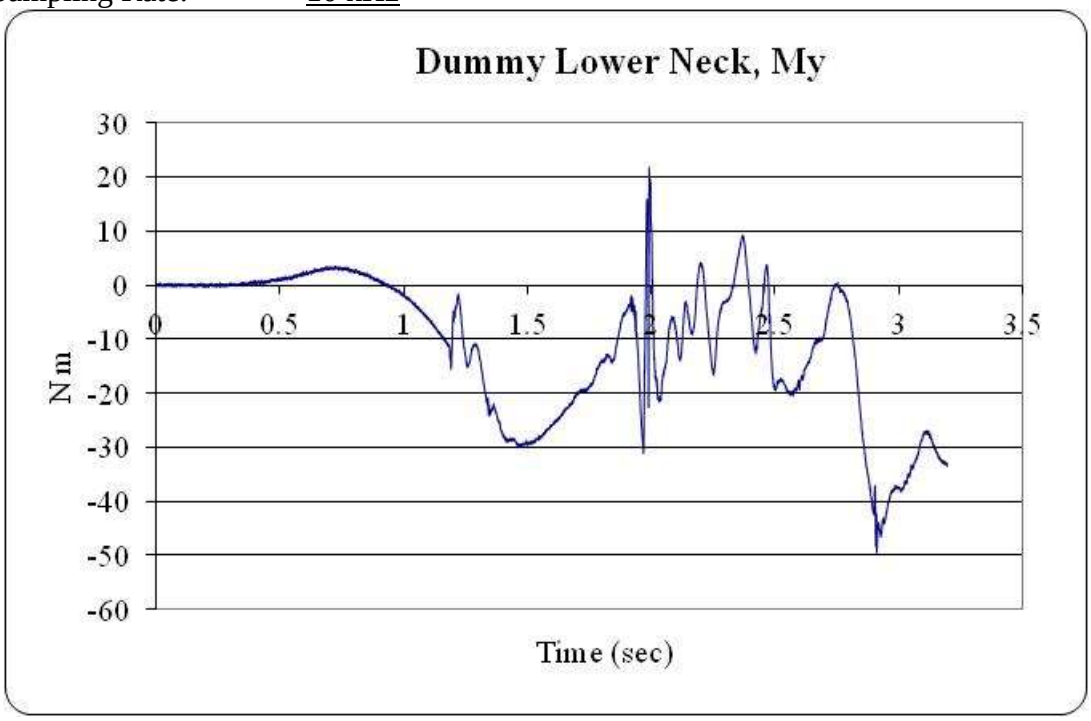
Data Sampling Rate: 10 kHz

Roll 1



Plot 7: Lower Neck Load, Mx, v. Time

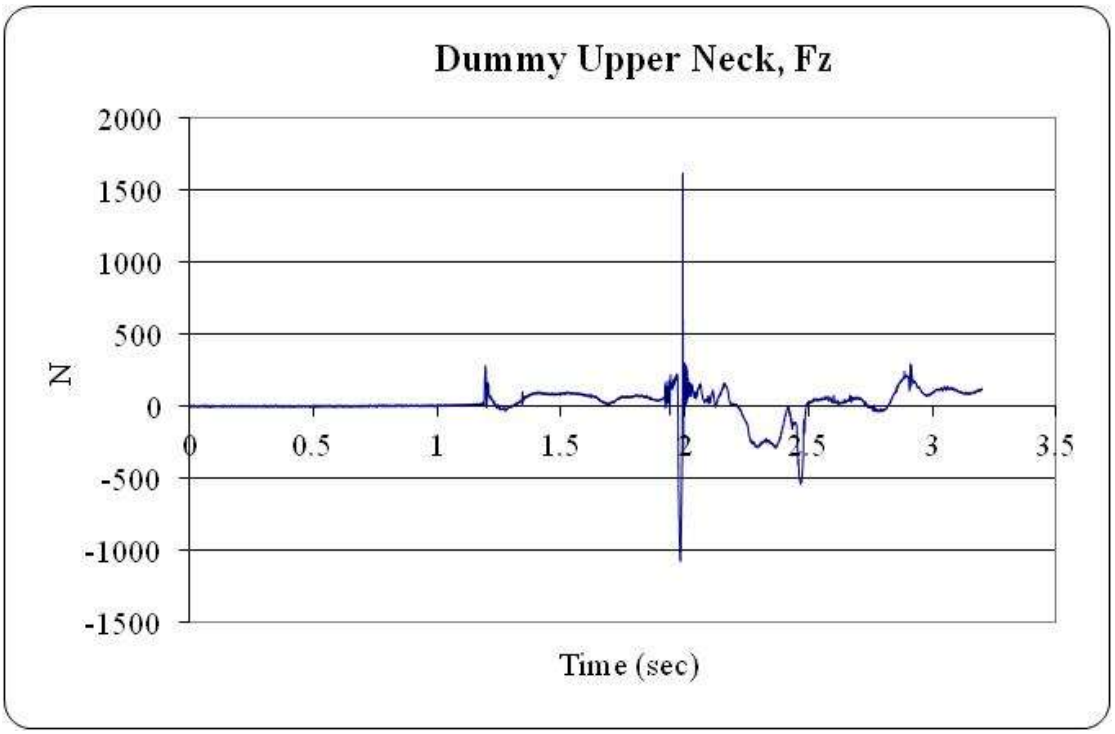
Data Sampling Rate: 10 kHz



Plot 8: Lower Neck Load, My, v. Time

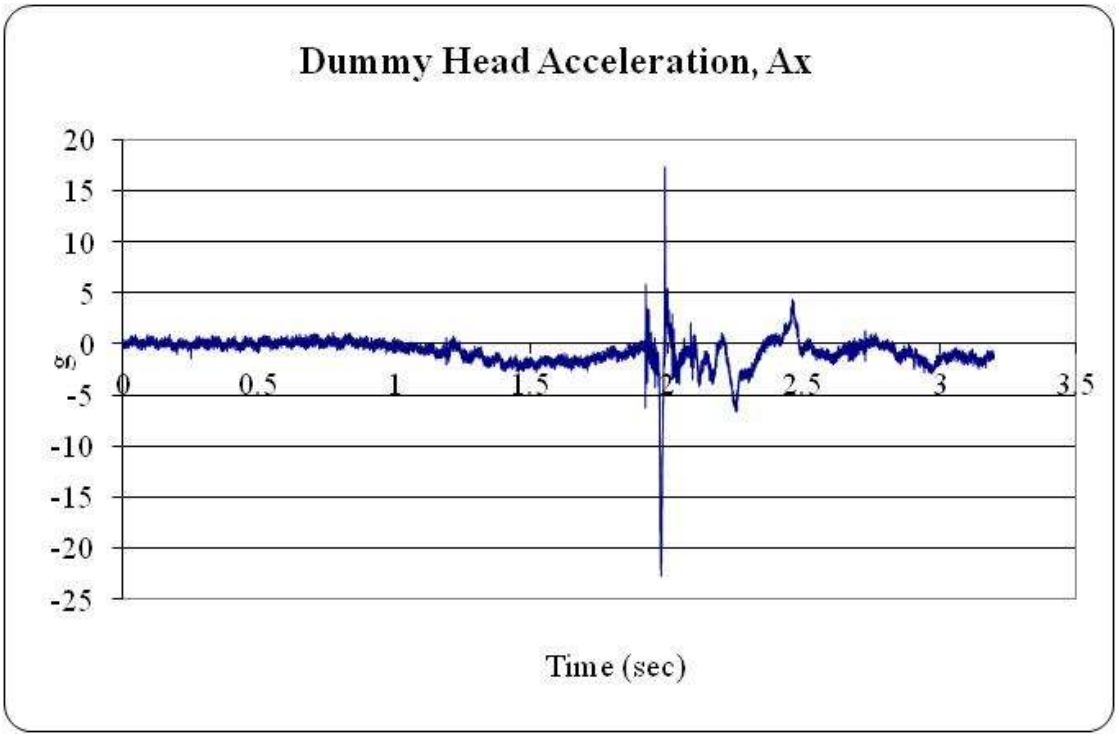
Data Sampling Rate: 10 kHz

Roll 1



Plot 9: Upper Neck Load, Fz, v. Time

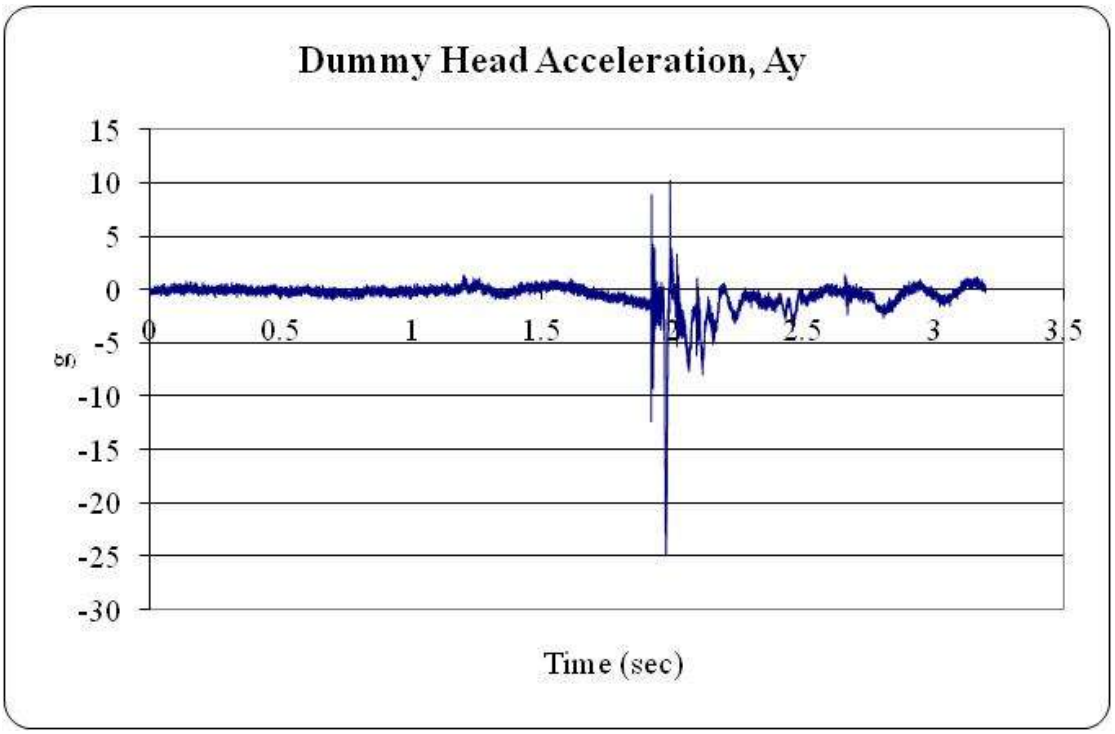
Data Sampling Rate: 10 kHz



Plot 10: Head Acceleration, Ax, vs. Time

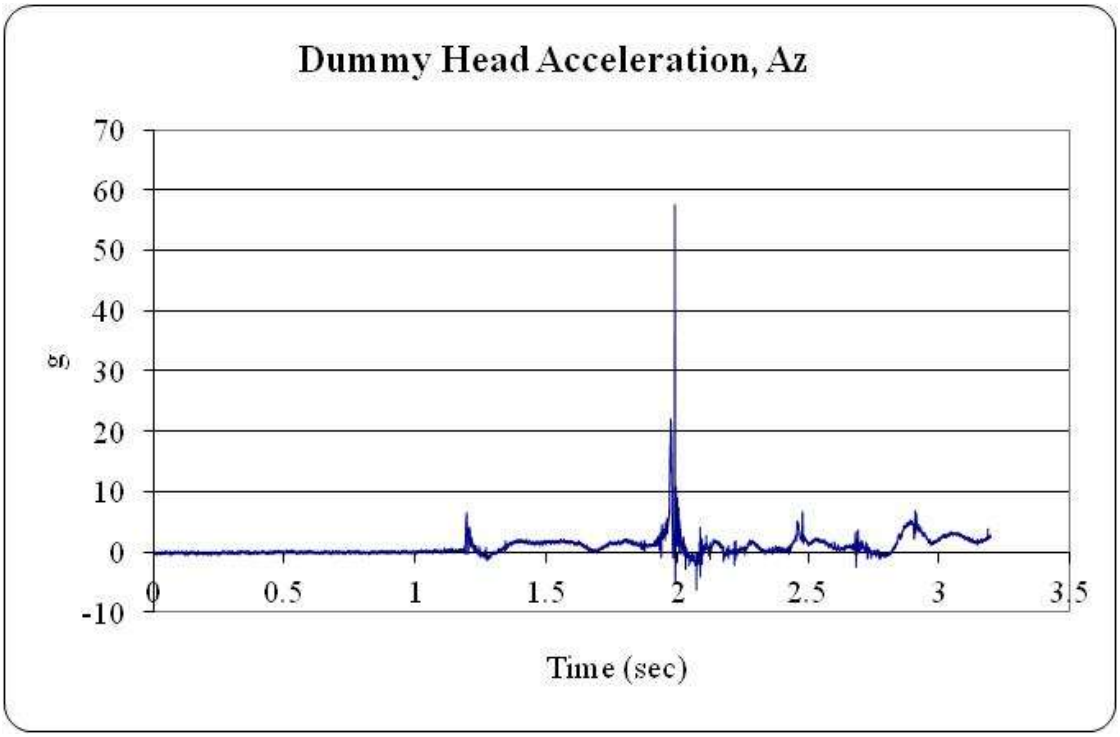
Data Sampling Rate: 10 kHz

Roll 1



Plot 11: Head Acceleration, Ay, vs. Time

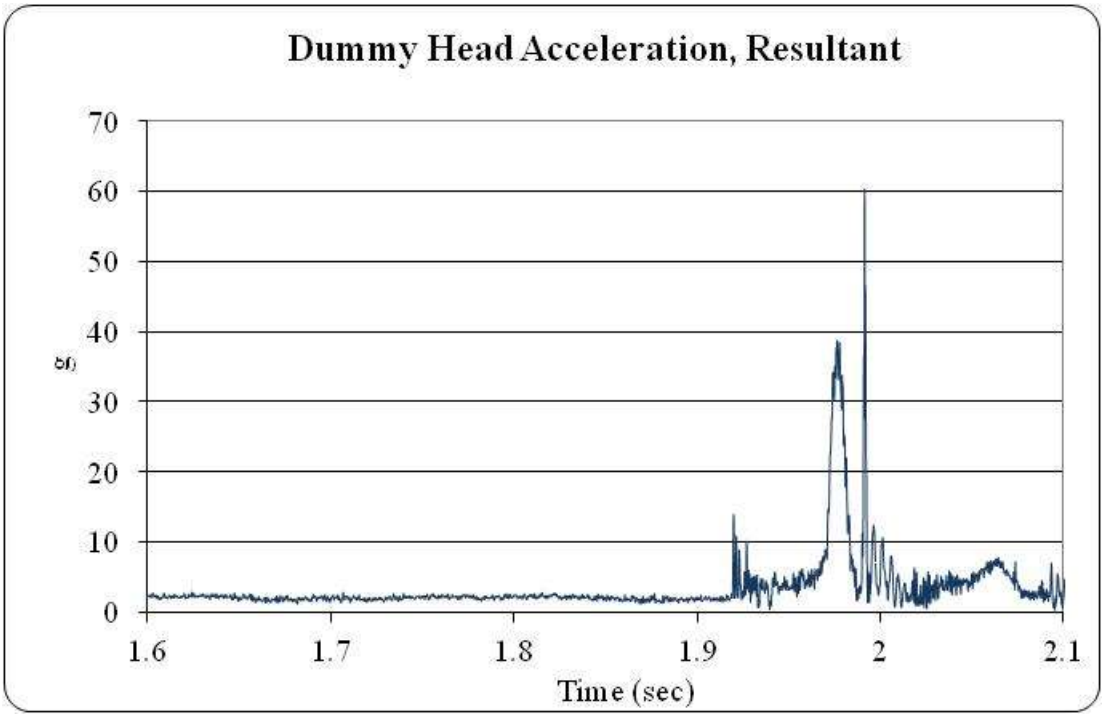
Data Sampling Rate: 10 kHz



Plot 12: Head Acceleration, Az, vs. Time

Data Sampling Rate: 10 kHz

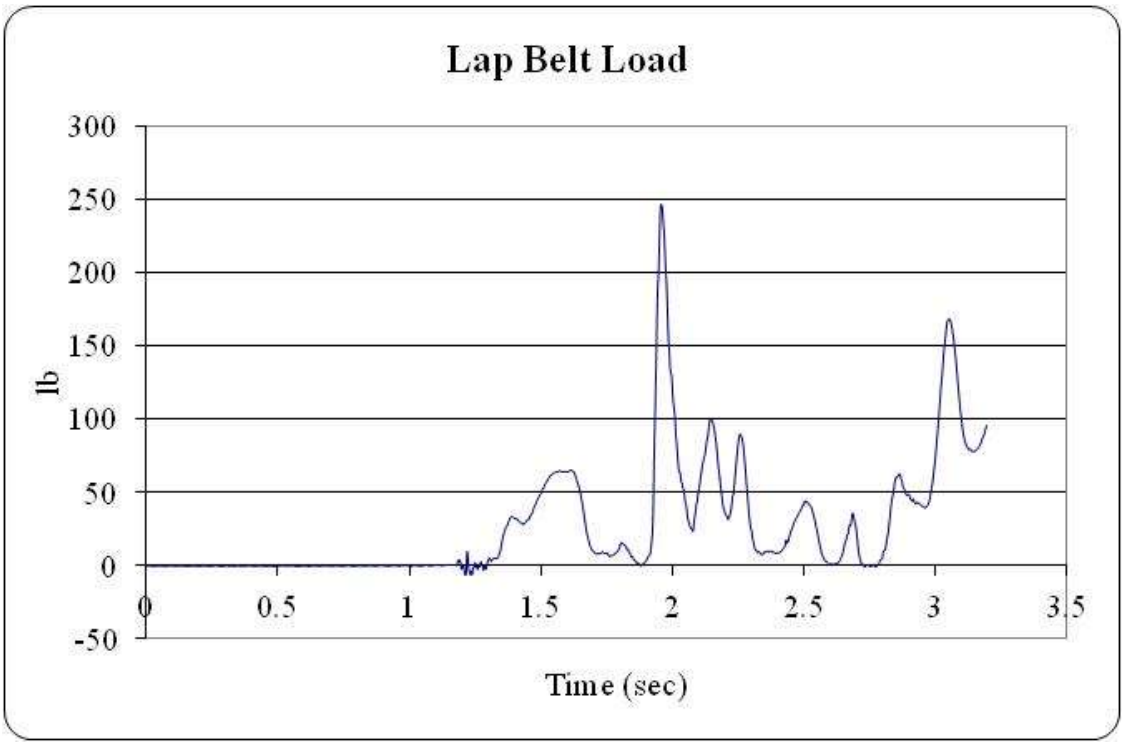
Roll 1



Plot 13: Resultant Head Acceleration vs. Time

HIC = 46

Data Sampling Rate: 10 kHz

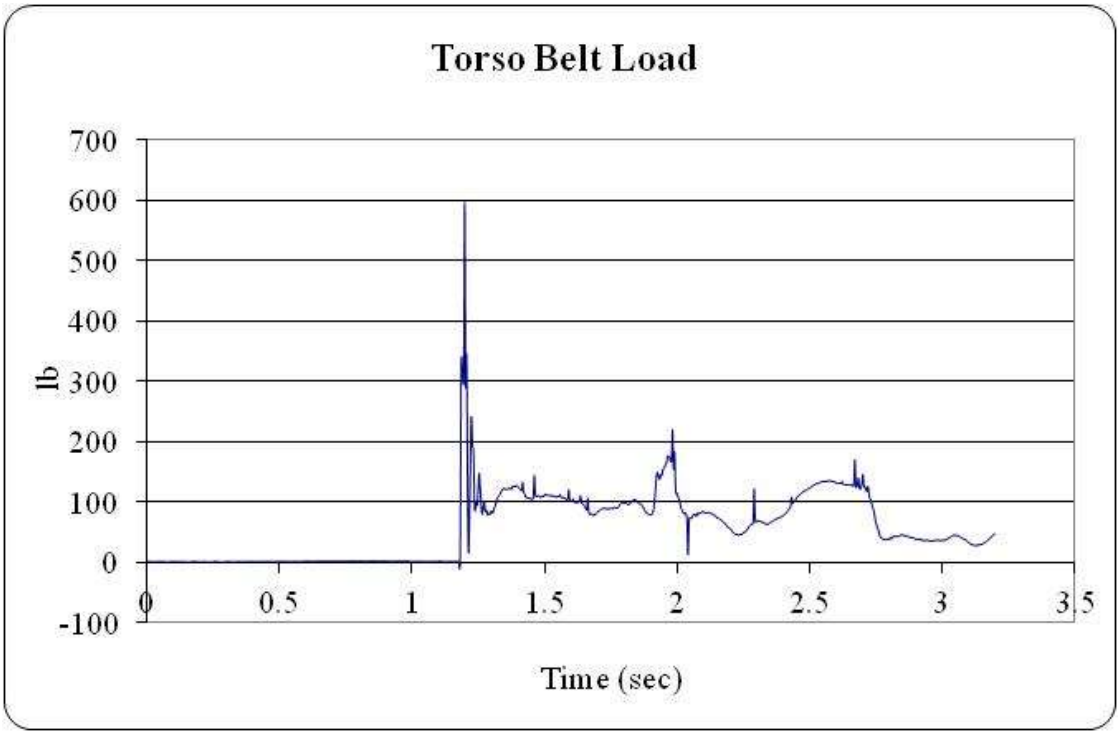


Plot 14: Lap Belt Load* vs. Time

*Measured on one side of the belt

Data Sampling Rate: 10 kHz

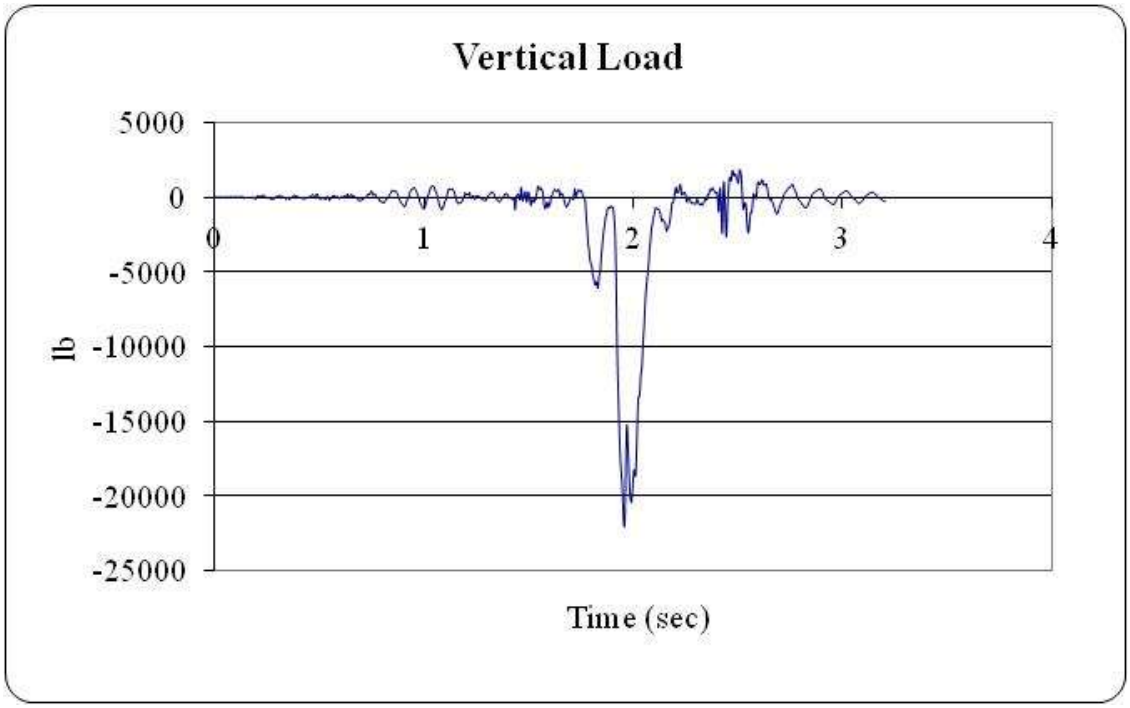
Roll 1



Plot 15: Torso Belt Load* vs. Time

*Measured on one side of the belt

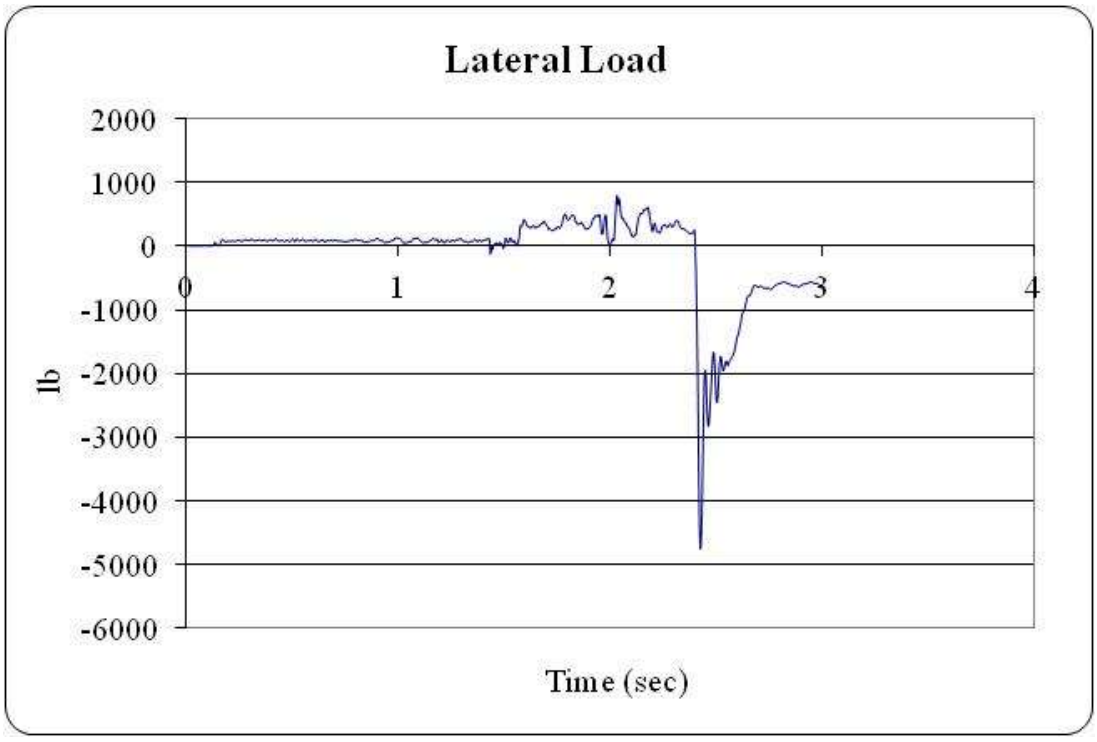
Data Sampling Rate: 10 kHz



Plot 16: Total Vertical Load v. Time

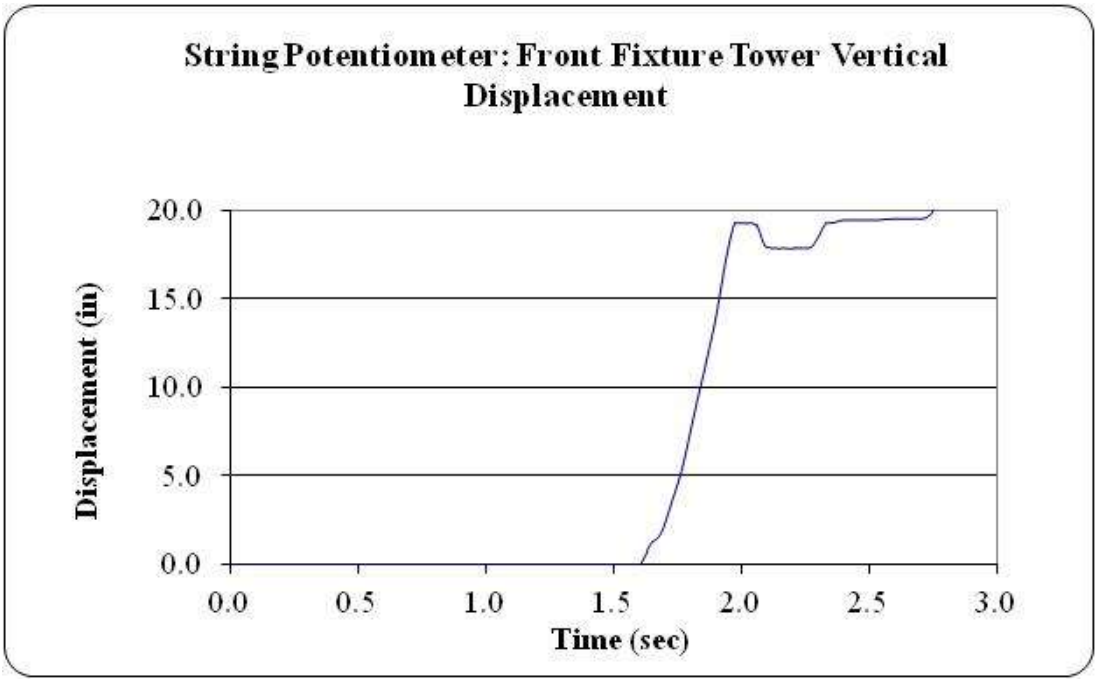
Data Sampling Rate: 10 kHz

Roll 1



Plot 17: Total Lateral Load v. Time

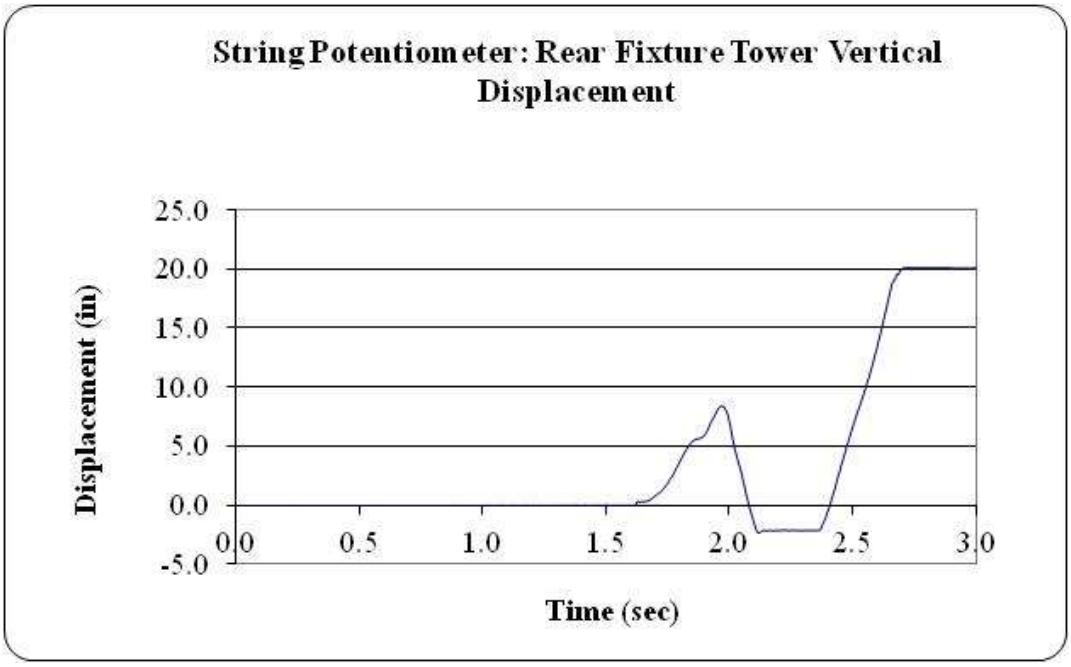
Data Sampling Rate: 10 kHz



Plot 18: String Potentiometer Front Fixture Support Tower Displacement vs. Time

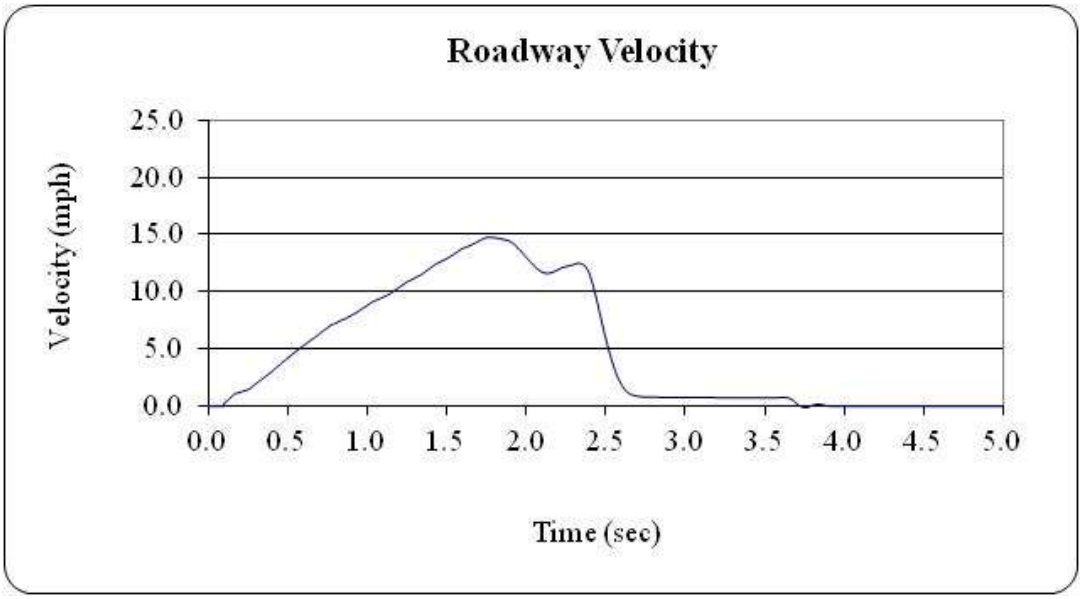
Data Sampling Rate: 1 kHz

Roll 1



Plot 19: String Potentiometer Rear Fixture Support Tower Displacement vs. Time

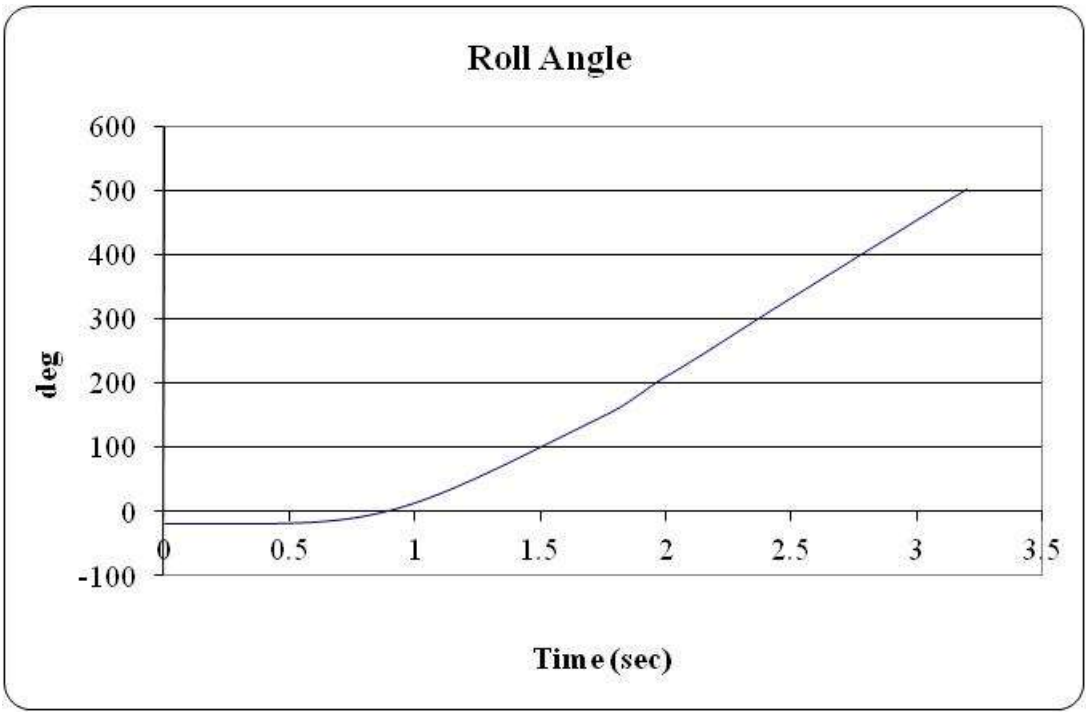
Data Sampling Rate: 1 kHz



Plot 20: Roll Encoder on Roadway Velocity vs. Time

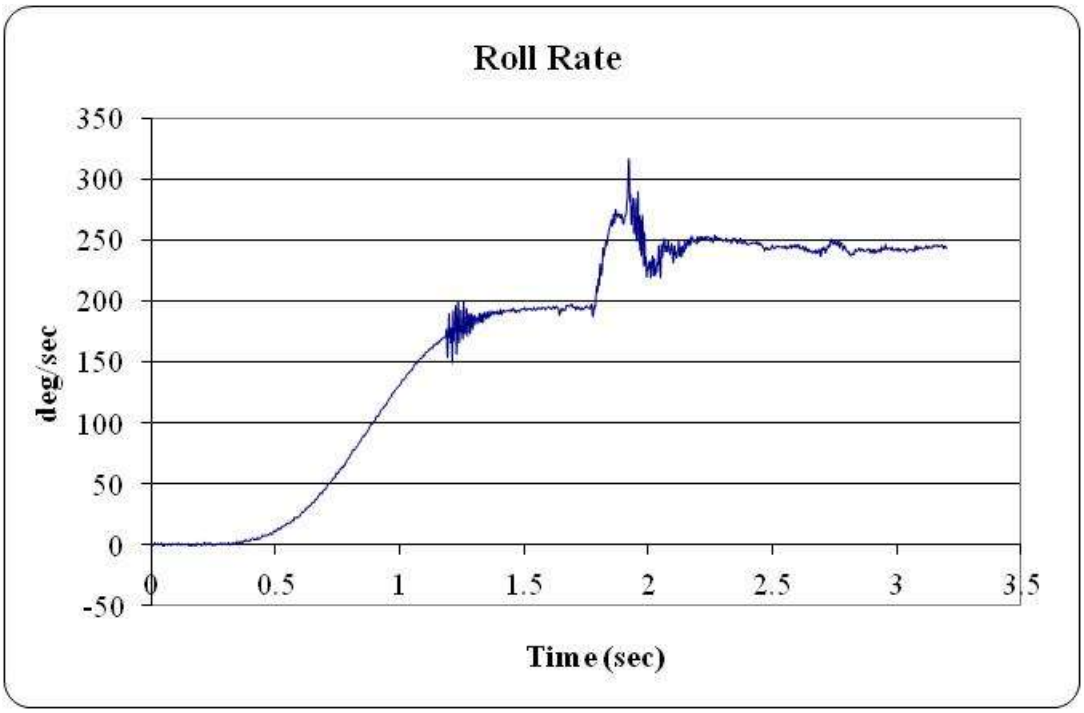
Data Sampling Rate: 1 kHz

Roll 1



Plot 21: Roll Angle vs. Time

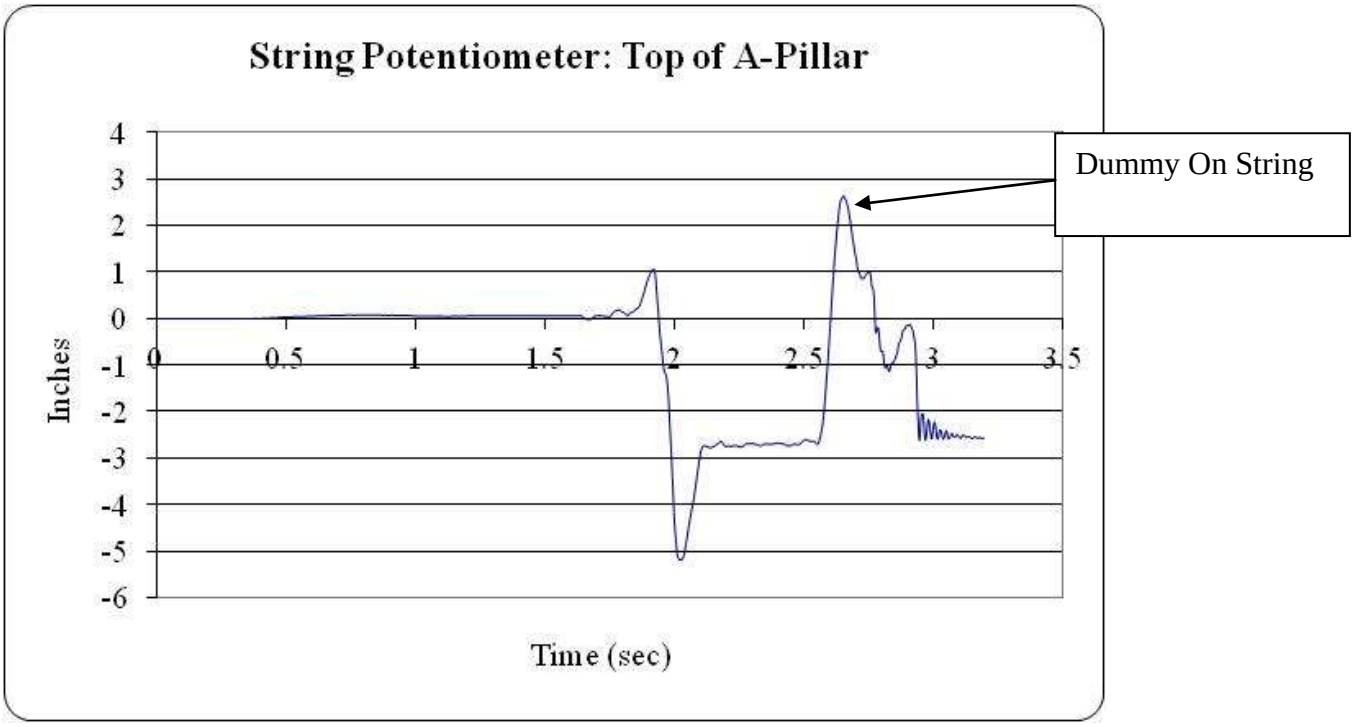
Data Sampling Rate: 10 kHz



Plot 22: Roll Rate vs. Time

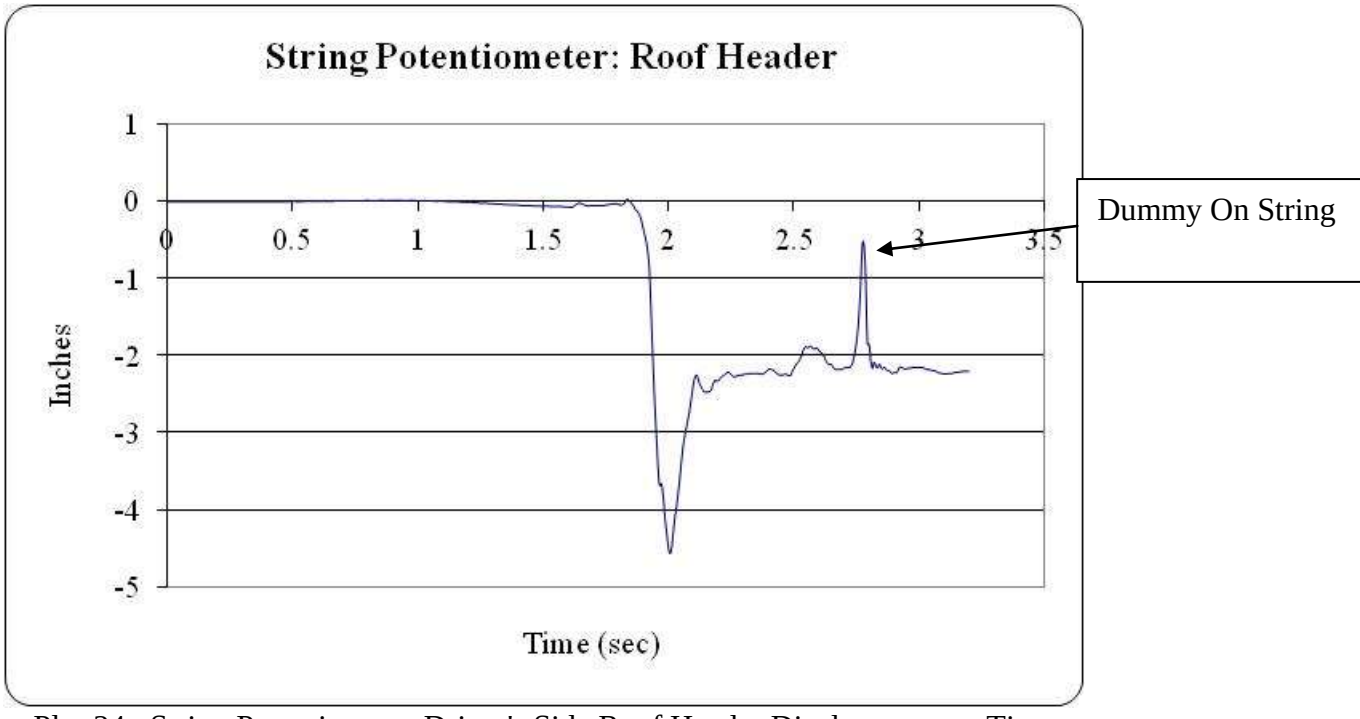
Data Sampling Rate: 10 kHz

Roll 2 Data Plots – 04/12/12



Plot 23: String Potentiometer Driver's Side A-Pillar Displacement v. Time

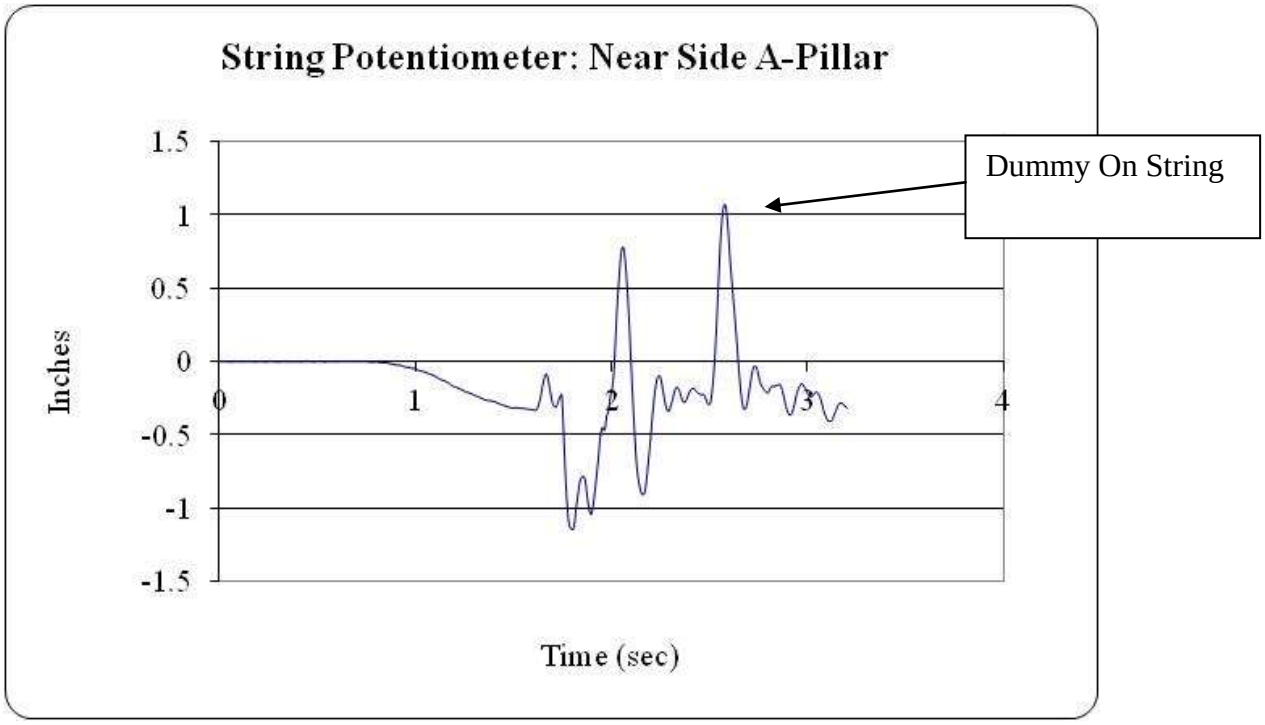
Data Sampling Rate: 10 kHz



Plot 24: String Potentiometer Driver's Side Roof Header Displacement v. Time

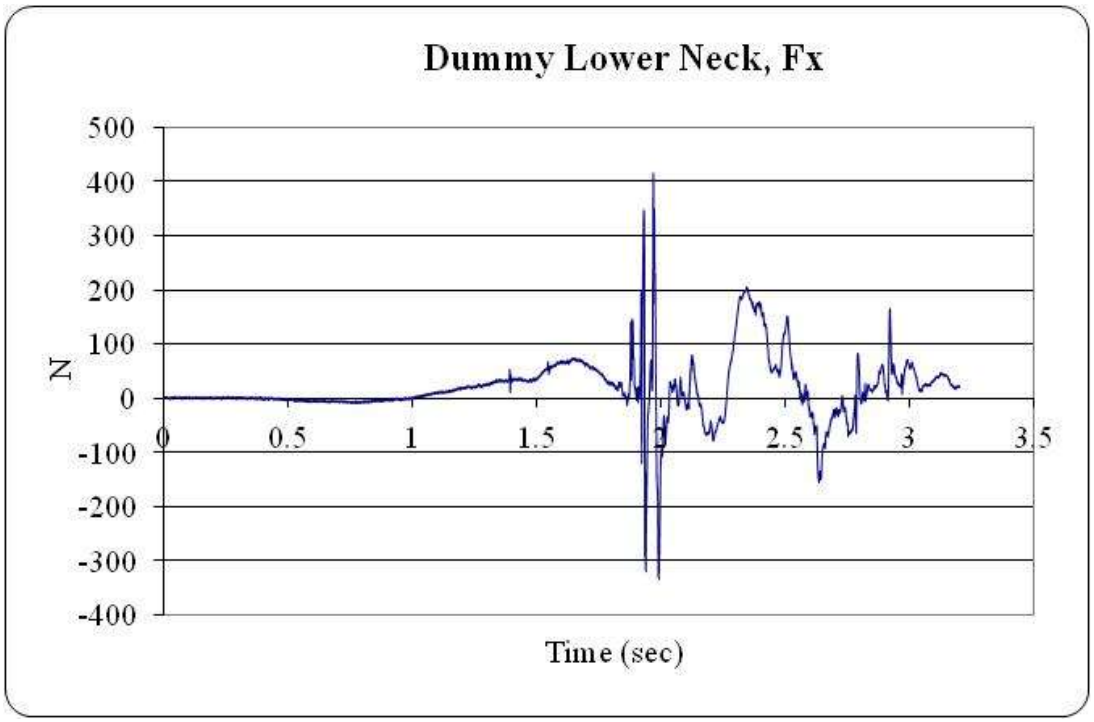
Data Sampling Rate: 10 kHz

Roll 2



Plot 25: String Potentiometer Passenger's Side A-Pillar Displacement v. Time

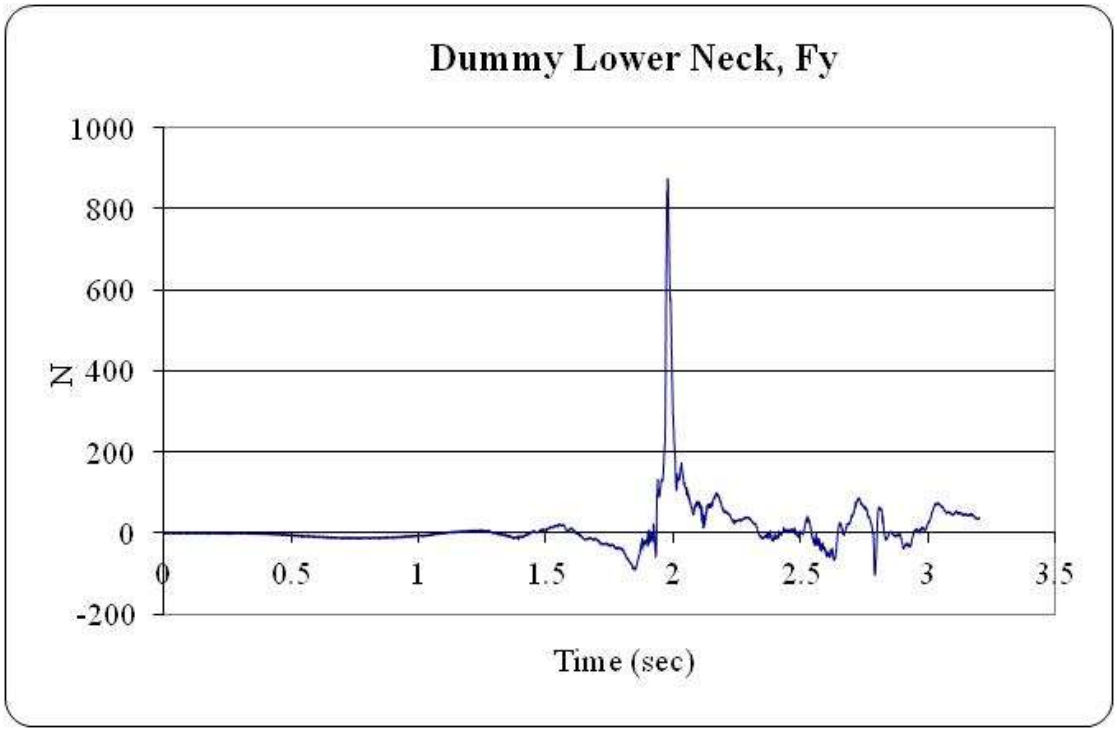
Data Sampling Rate: 10 kHz



Plot 26: Lower Neck Load, Fx, v. Time

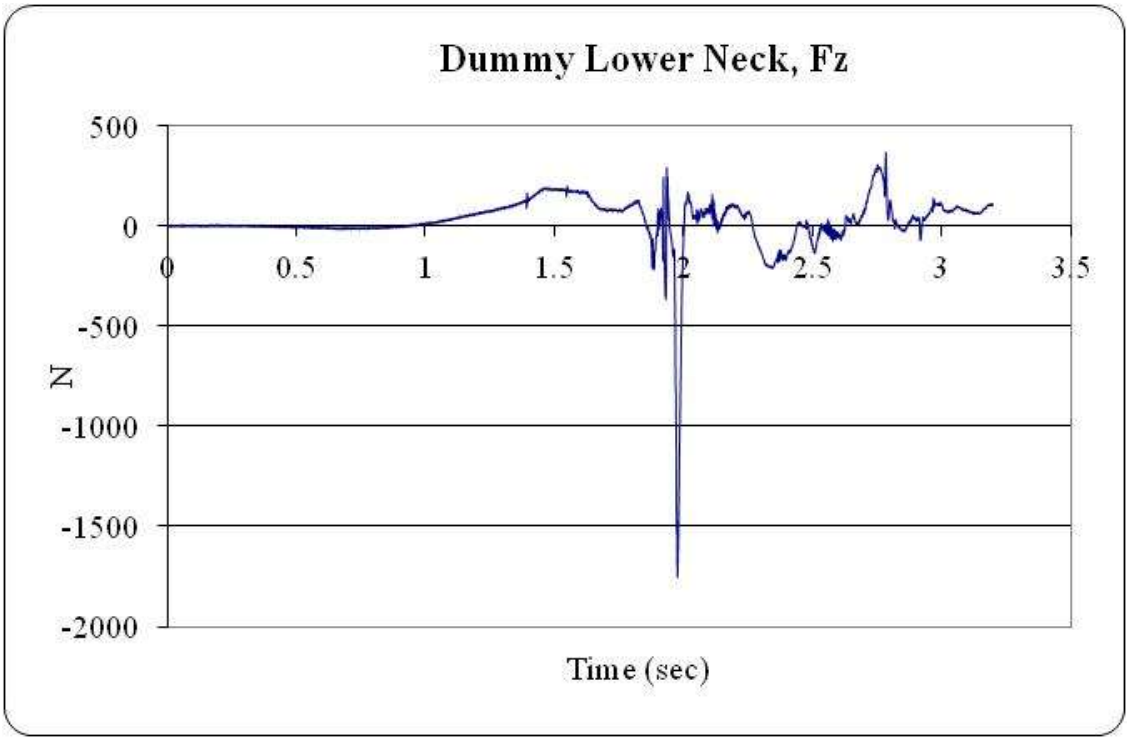
Data Sampling Rate: 10 kHz

Roll 2



Plot 27: Lower Neck Load, Fy, v. Time

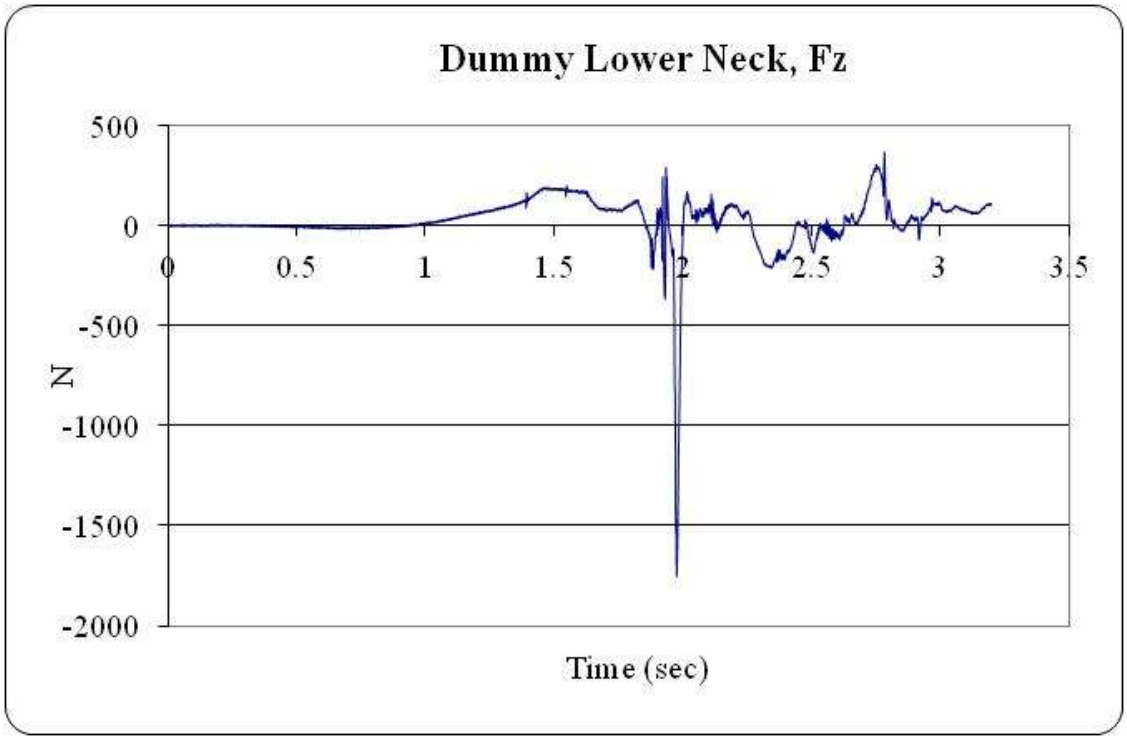
Data Sampling Rate: 10 kHz



Plot 28: Lower Neck Load, Fz, v. Time

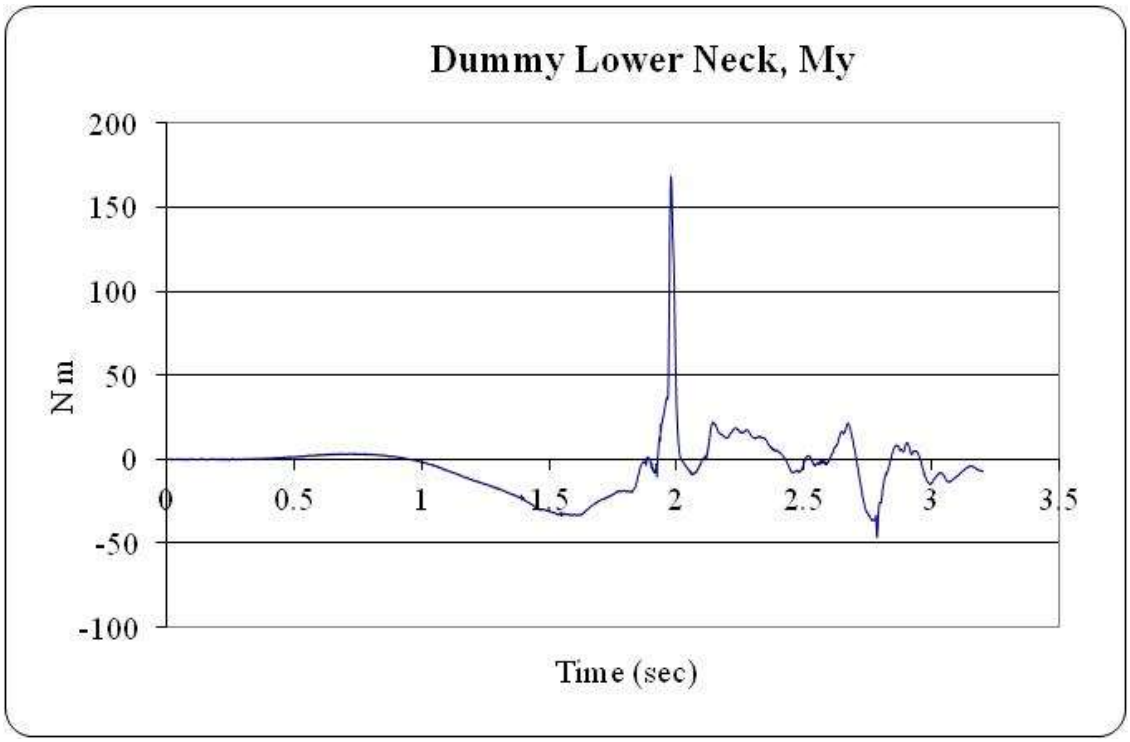
Data Sampling Rate: 10 kHz

Roll 2



Plot 29: Lower Neck Load, Mx, v. Time

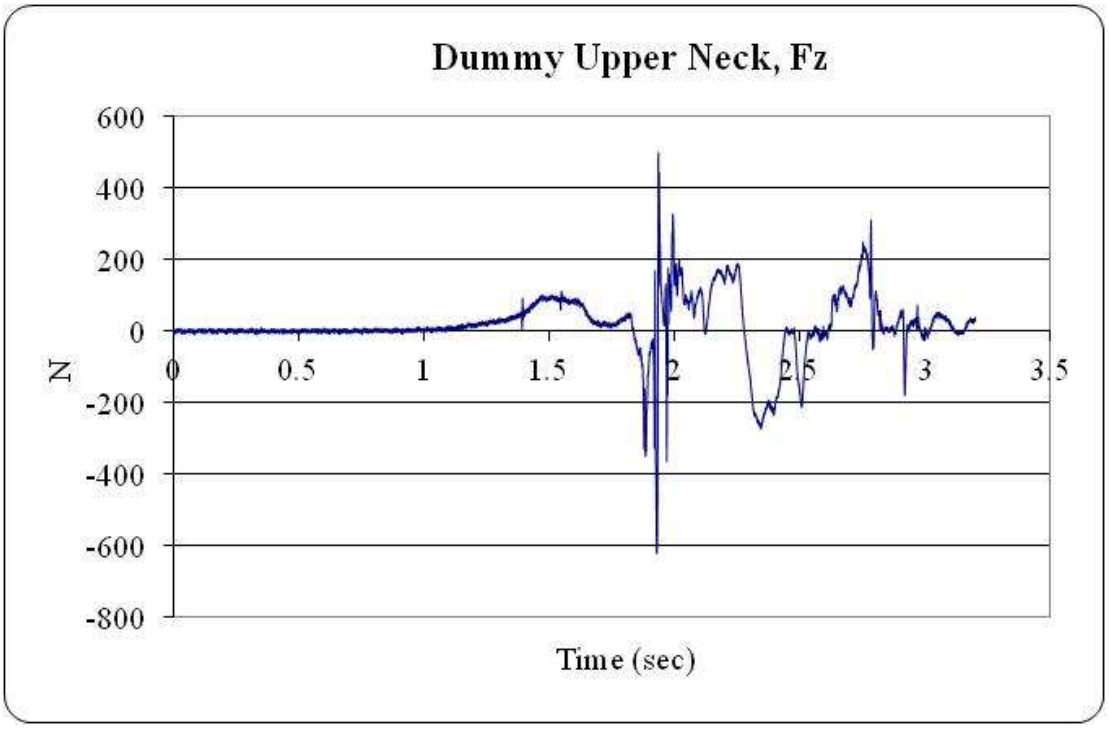
Data Sampling Rate: 10 kHz



Plot 30: Lower Neck Load, My, v. Time

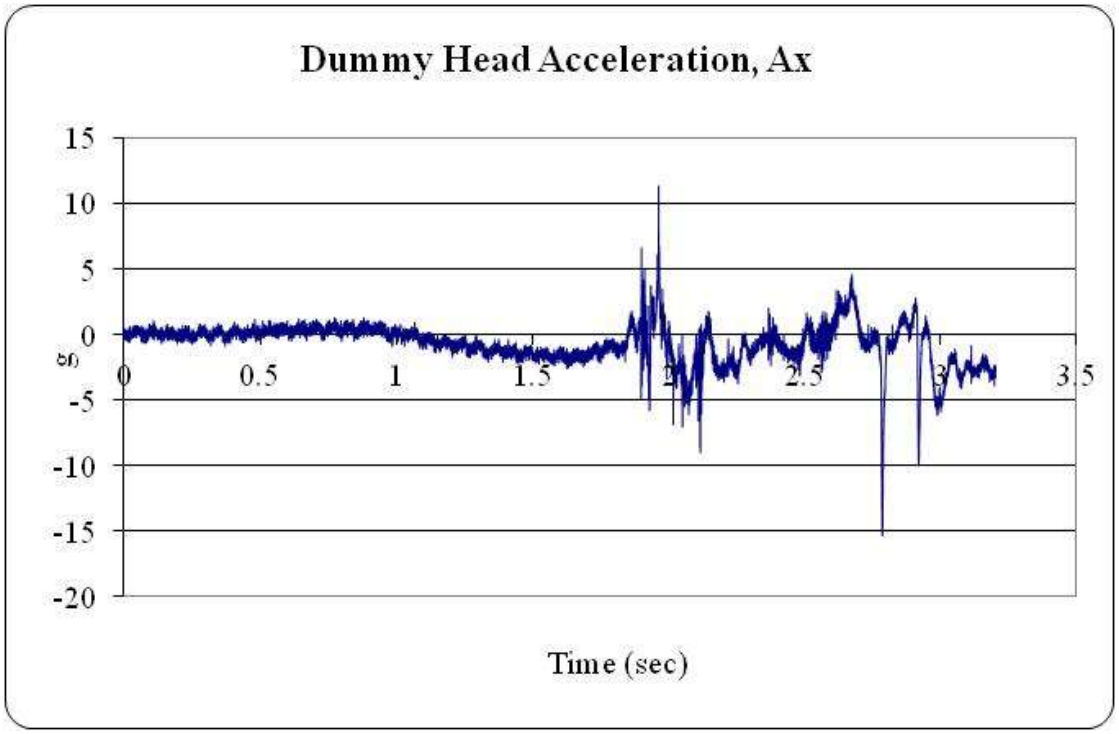
Data Sampling Rate: 10 kHz

Roll 2



Plot 31: Upper Neck Load, Fz, v. Time

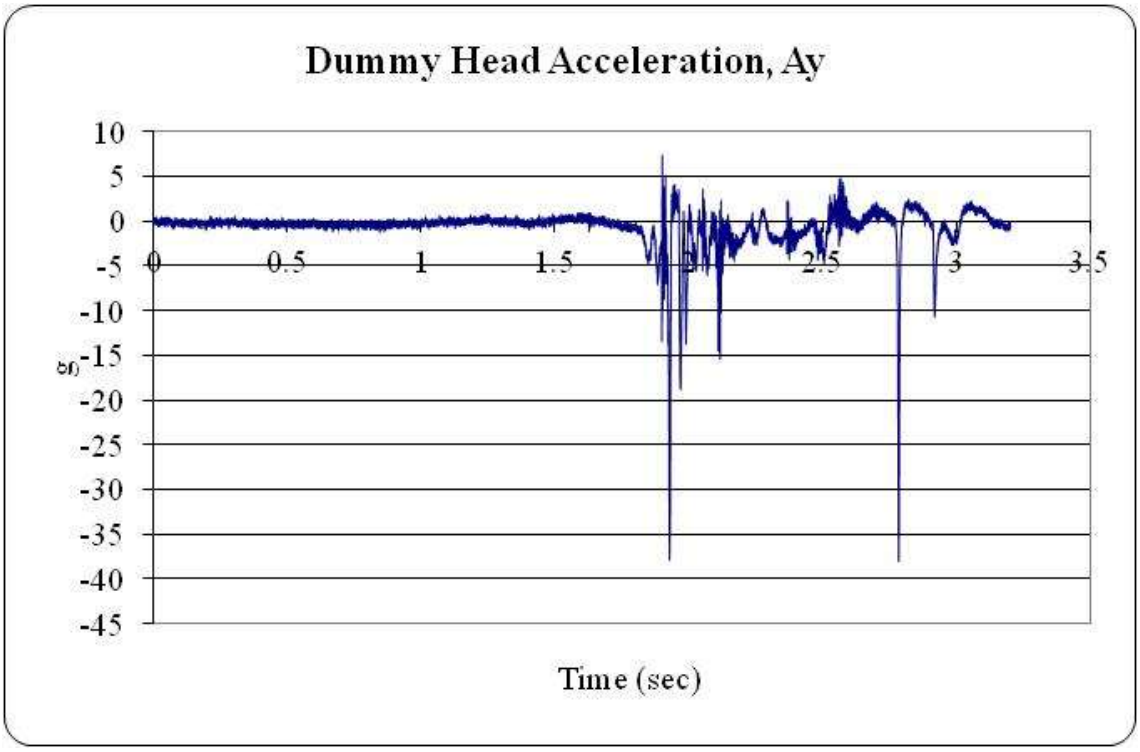
Data Sampling Rate: 10 kHz



Plot 32: Head Acceleration, Ax, vs. Time

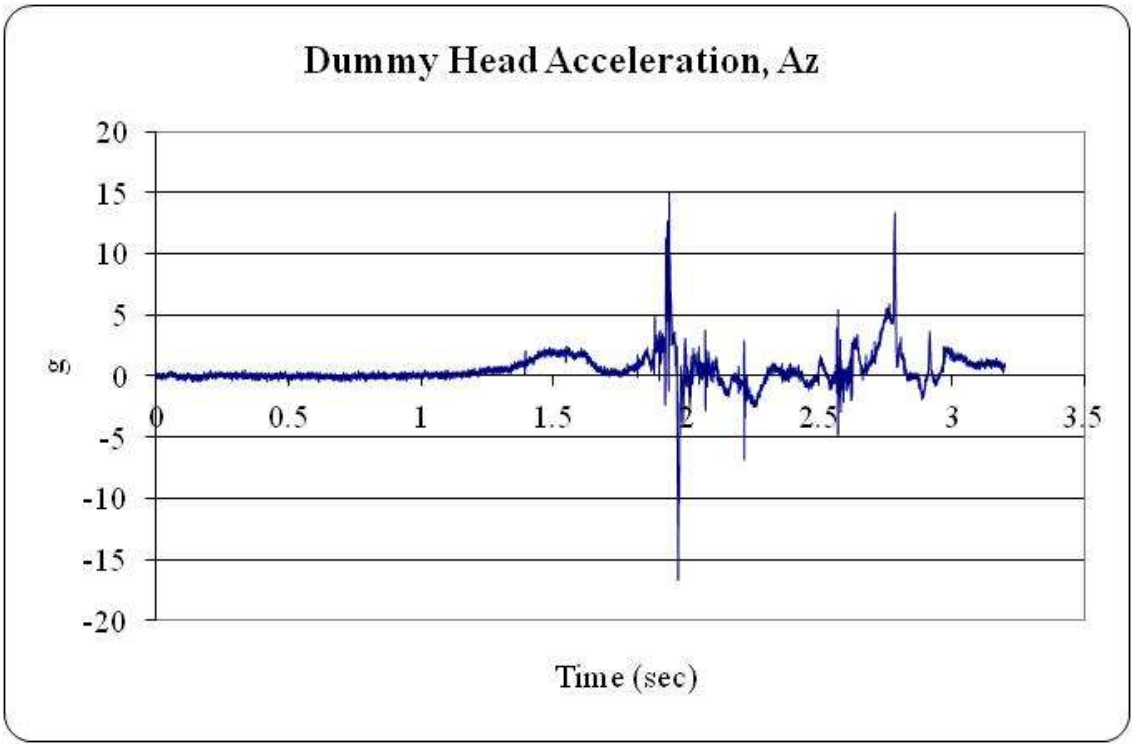
Data Sampling Rate: 10 kHz

Roll 2



Plot 33: Head Acceleration, Ay, vs. Time

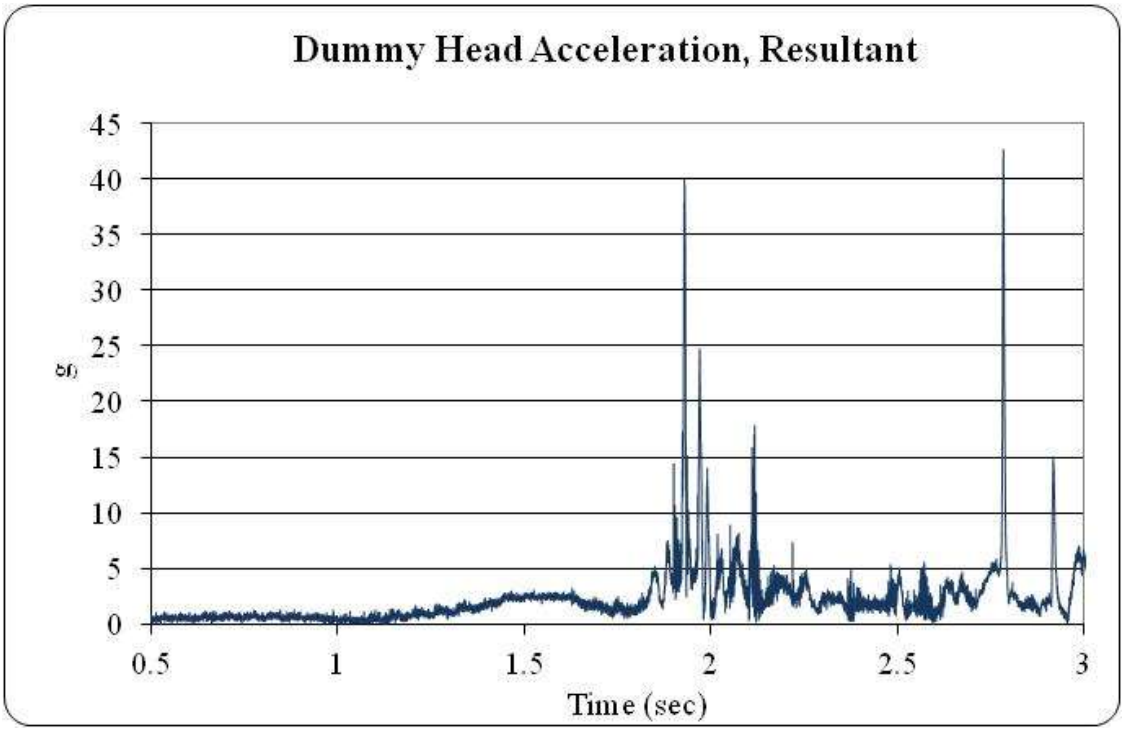
Data Sampling Rate: 10 kHz



Plot 34: Head Acceleration, Az, vs. Time

Data Sampling Rate: 10 kHz

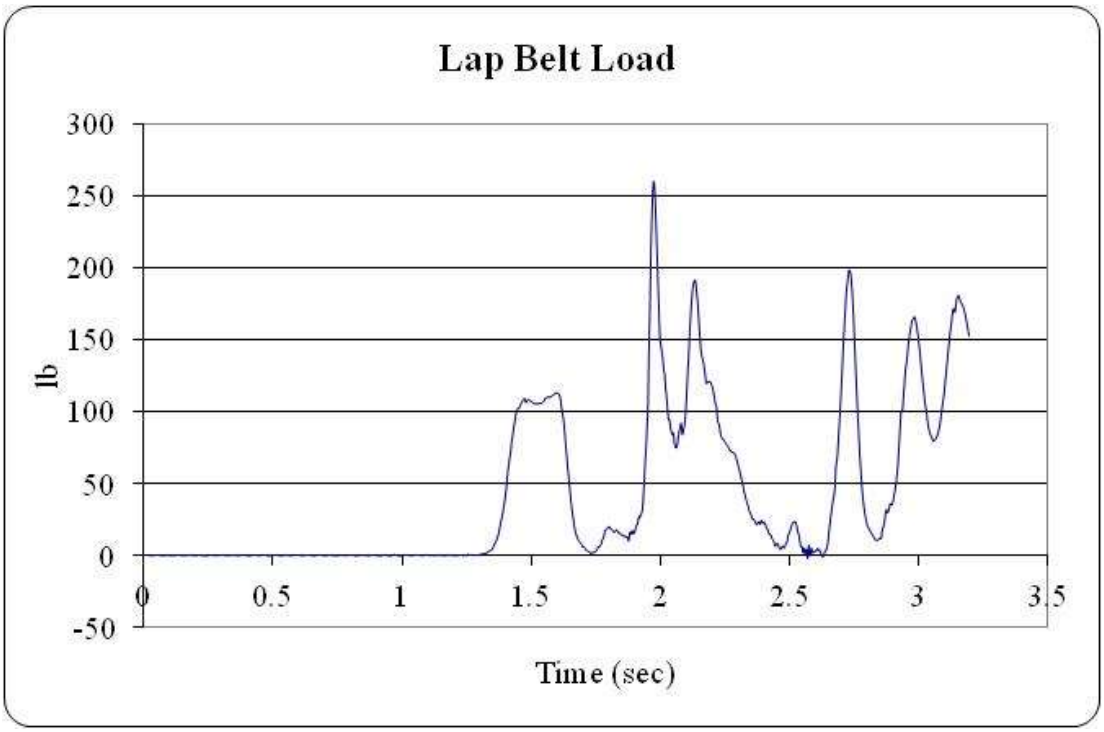
Roll 2



Plot 35: Resultant Head Acceleration vs. Time

HIC = 36

Data Sampling Rate: 10 kHz

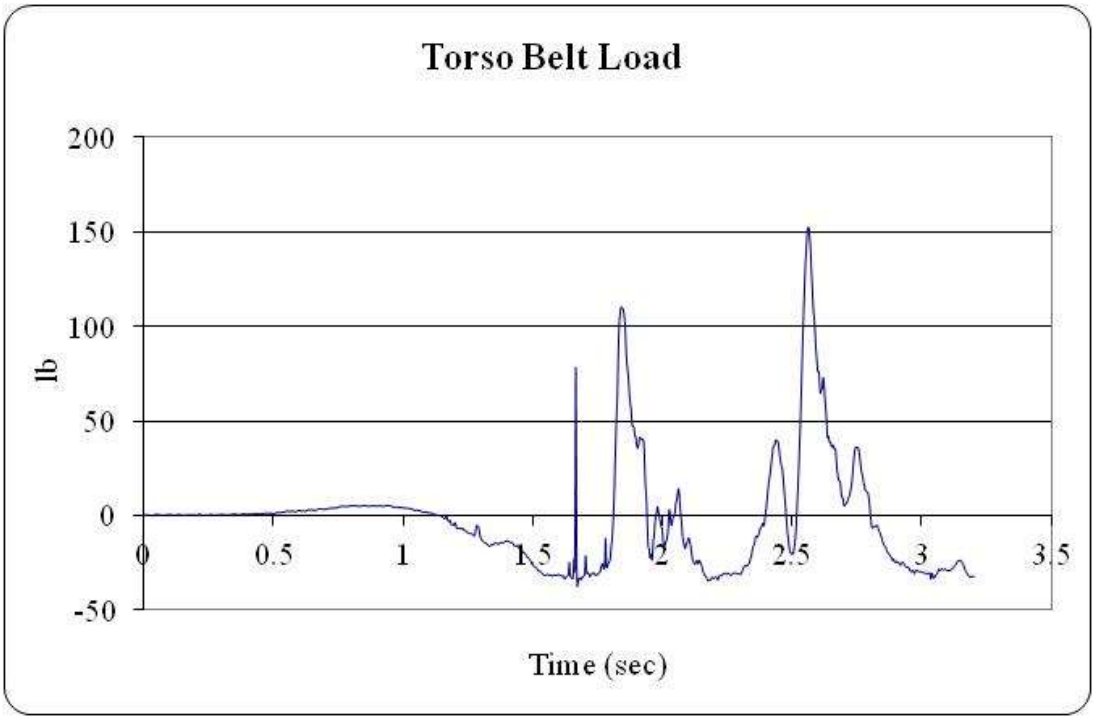


Plot 36: Lap Belt Load* vs. Time

*Measured on one side of the belt

Data Sampling Rate: 10 kHz

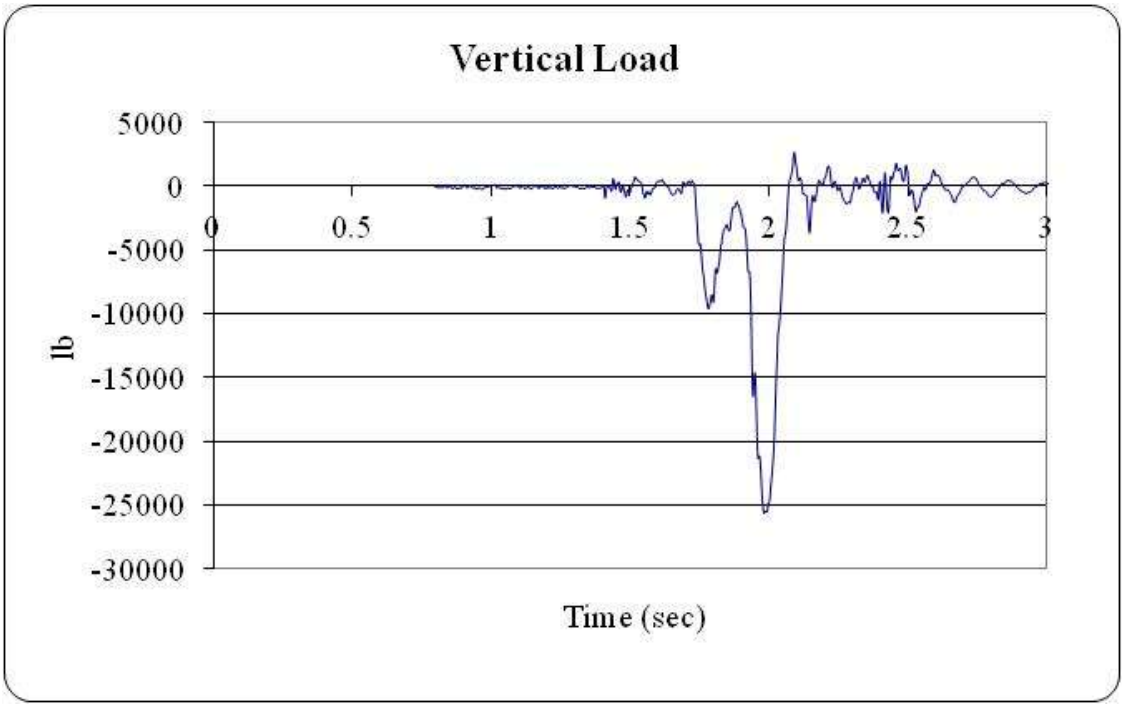
Roll 2



Plot 37: Torso Belt Load* vs. Time

*Measured on one side of the belt

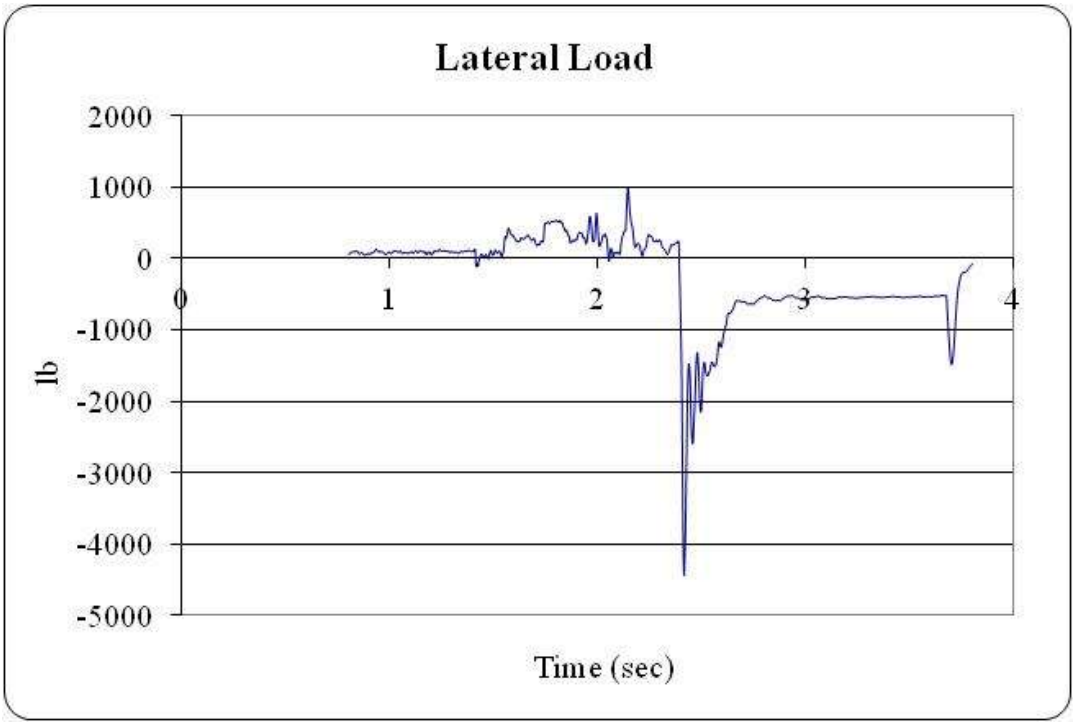
Data Sampling Rate: 10 kHz



Plot 38: Total Vertical Load v. Time

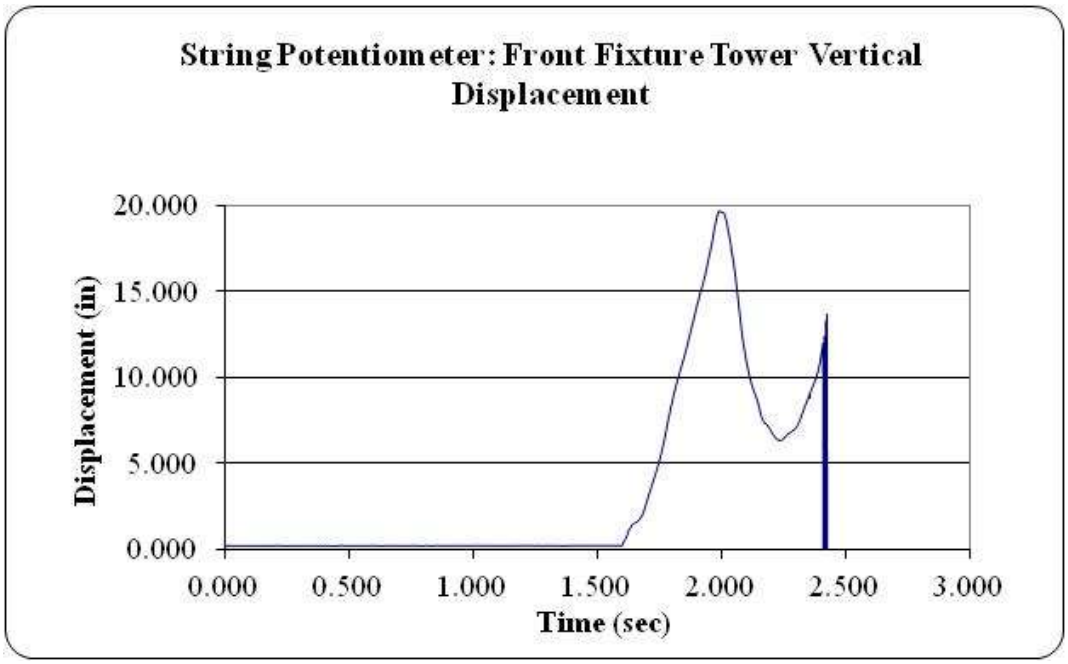
Data Sampling Rate: 10 kHz

Roll 2



Plot 39: Total Lateral Load v. Time

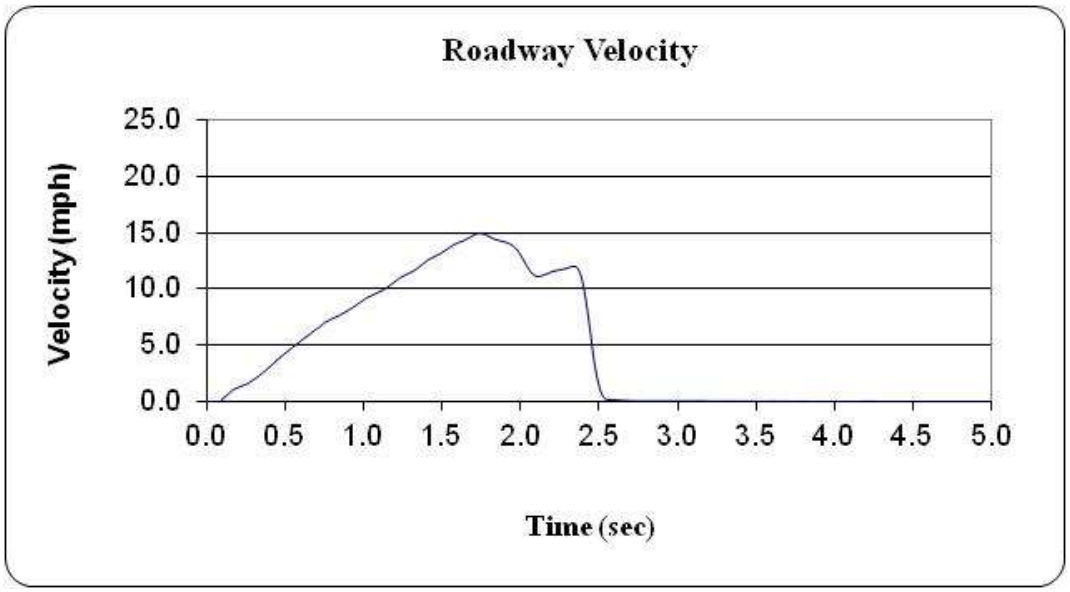
Data Sampling Rate: 10 kHz



Plot 40: String Potentiometer Front Fixture Support Tower Displacement vs. Time

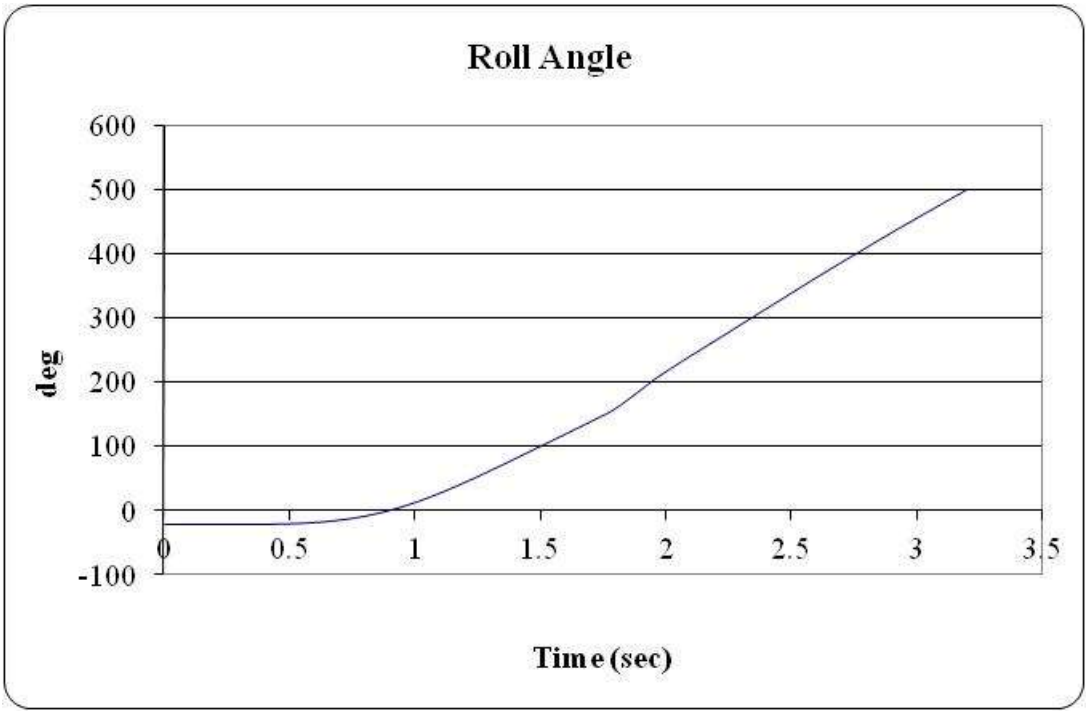
Data Sampling Rate: 1 kHz

Roll 2



Plot 41: Roll Encoder on Roadway Velocity vs. Time

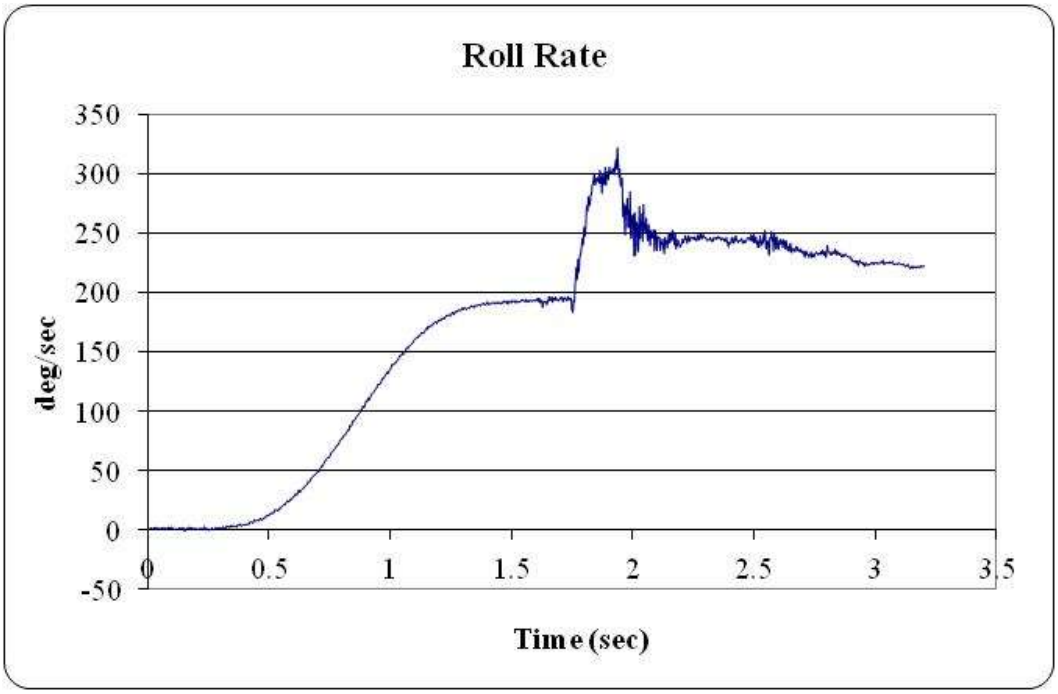
Data Sampling Rate: 1 kHz



Plot 42: Roll Angle vs. Time

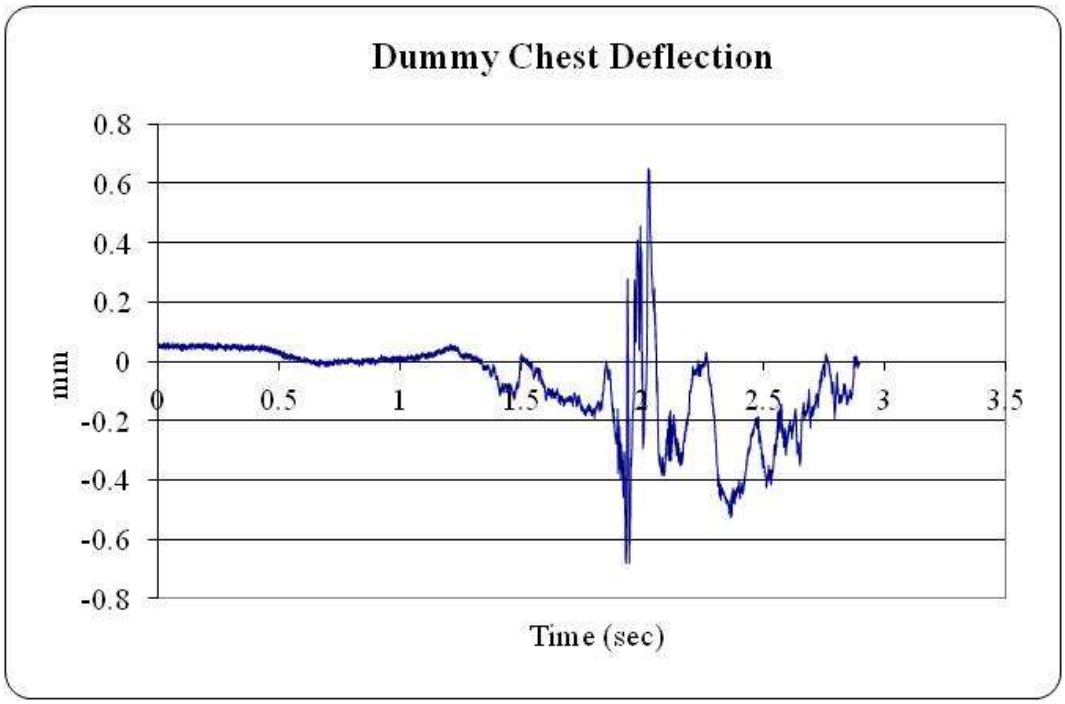
Data Sampling Rate: 10 kHz

Roll 2



Plot 43: Roll Rate vs. Time

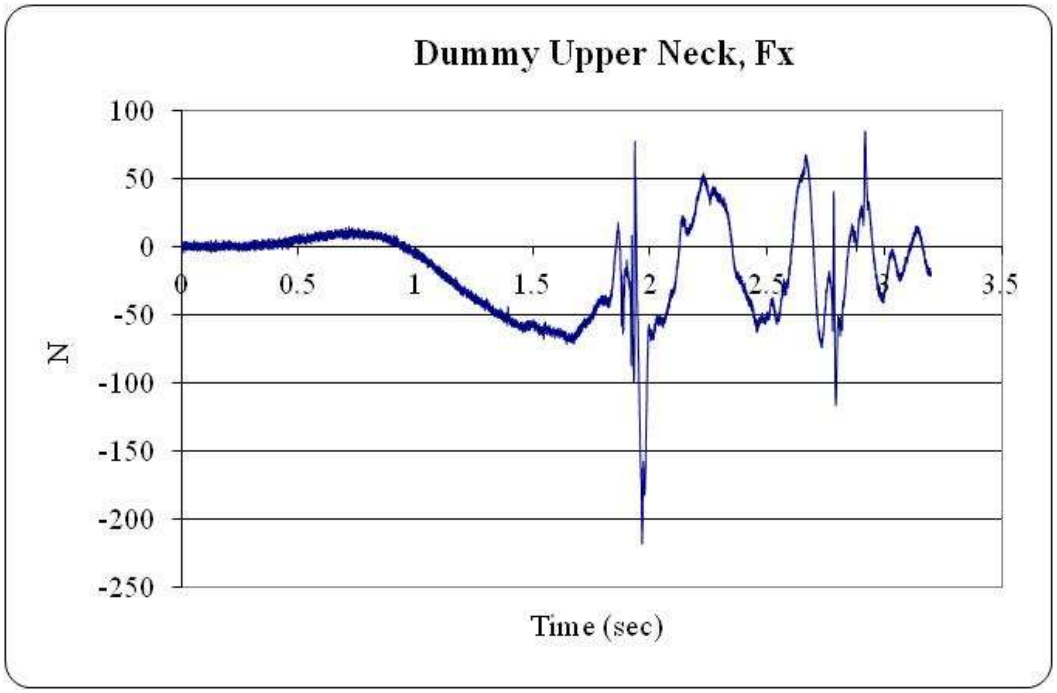
Data Sampling Rate: 10 kHz



Plot 44: Chest Deflection vs. Time

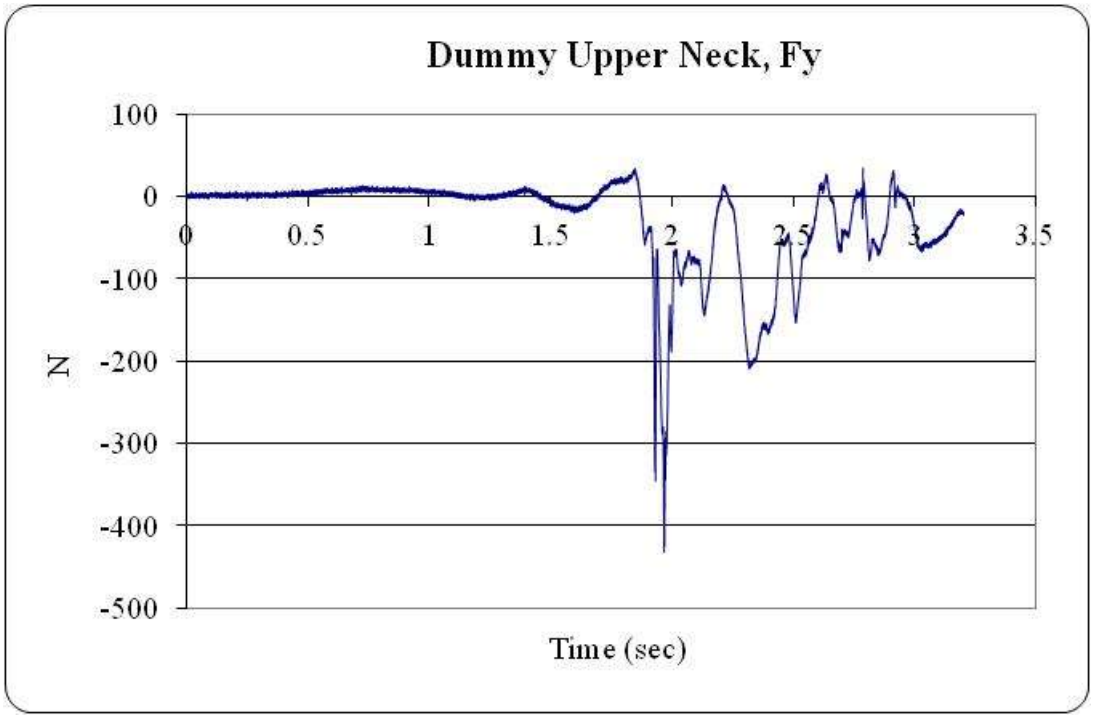
Data Sampling Rate: 10 kHz

Roll 2



Plot 45: Dummy Upper Neck Loading, Fx vs. Time

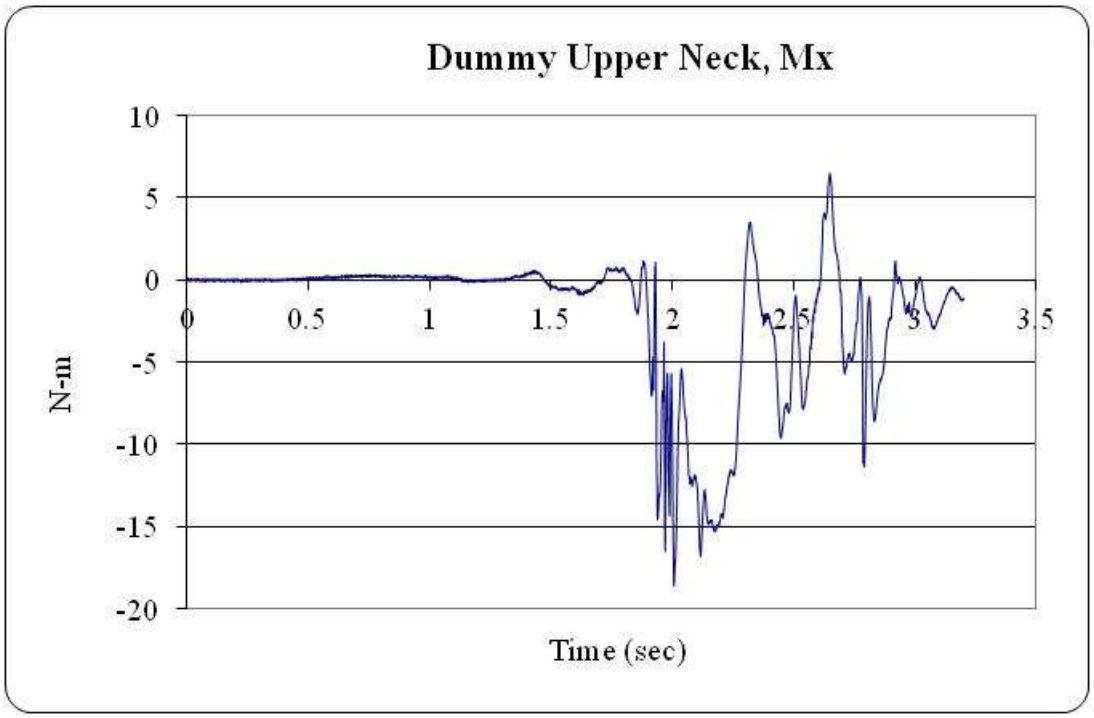
Data Sampling Rate: 10 kHz



Plot 46: Dummy Upper Neck Loading, Fy vs. Time

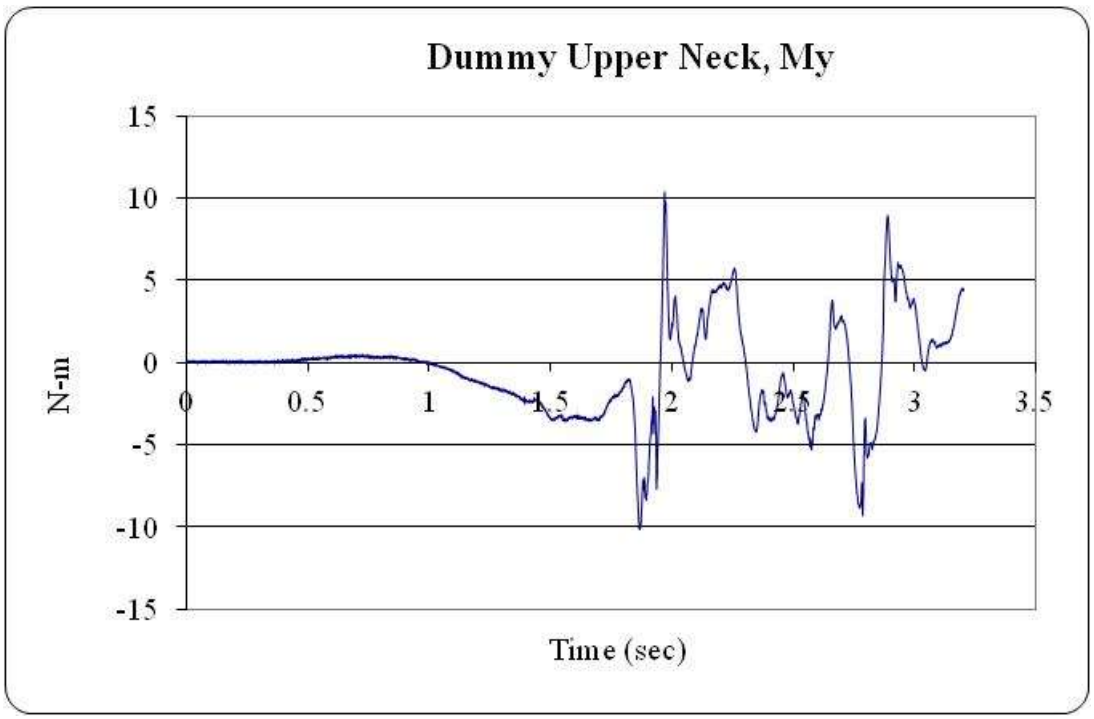
Data Sampling Rate: 10 kHz

Roll 2



Plot 47: Dummy Upper Neck Bending Moment, Mx vs. Time

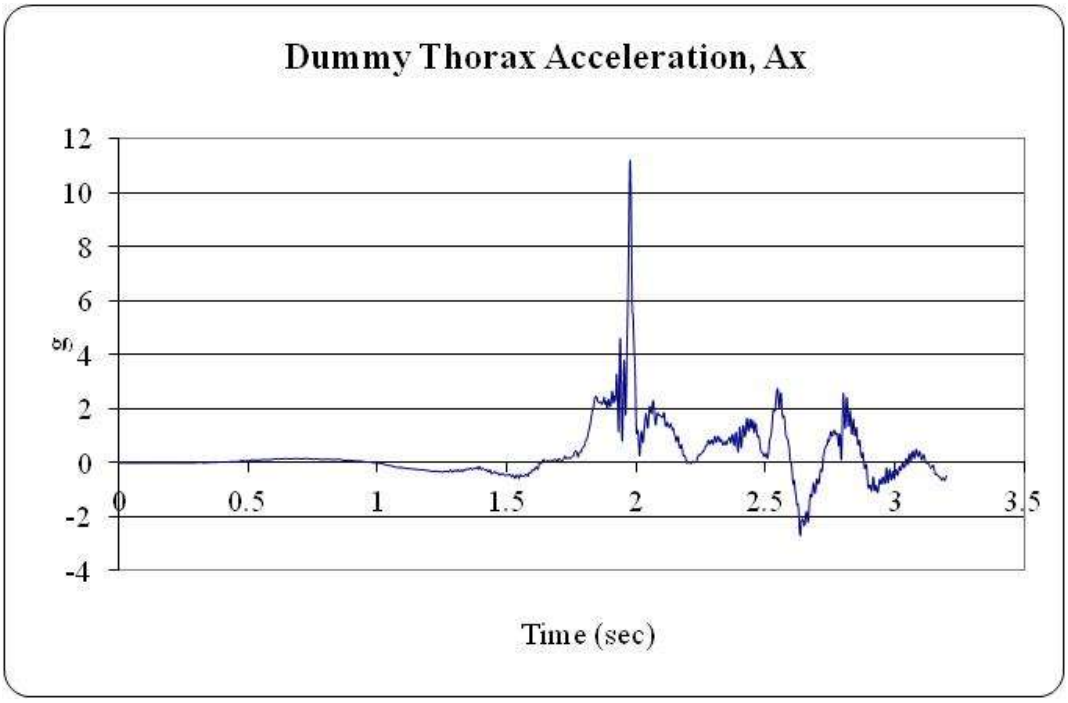
Data Sampling Rate: 10 kHz



Plot 48: Dummy Upper Neck Bending Moment, My vs. Time

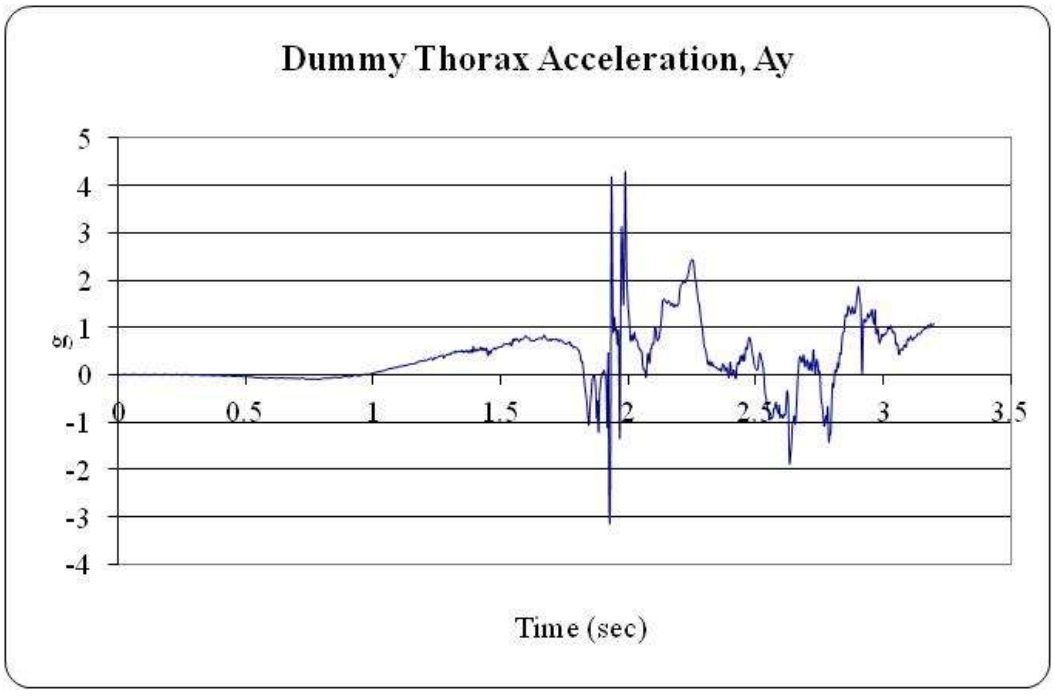
Data Sampling Rate: 10 kHz

Roll 2



Plot 49: Dummy Thorax Acceleration, Ax vs. Time

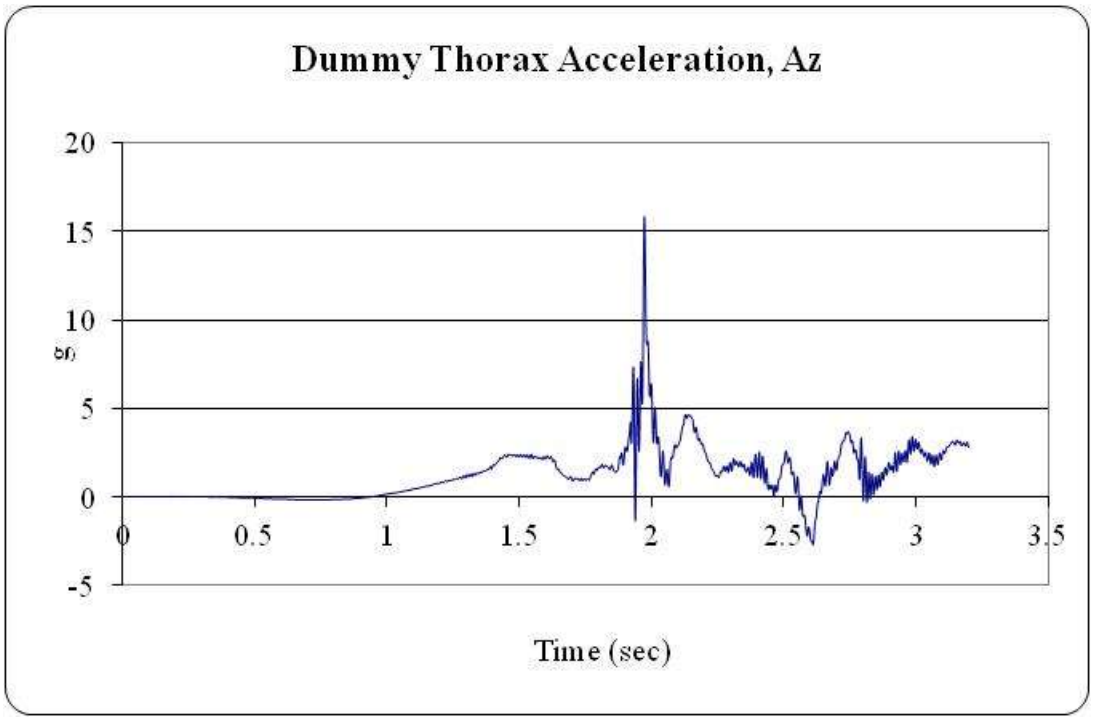
Data Sampling Rate: 10 kHz



Plot 50: Dummy Thorax Acceleration, Ay vs. Time

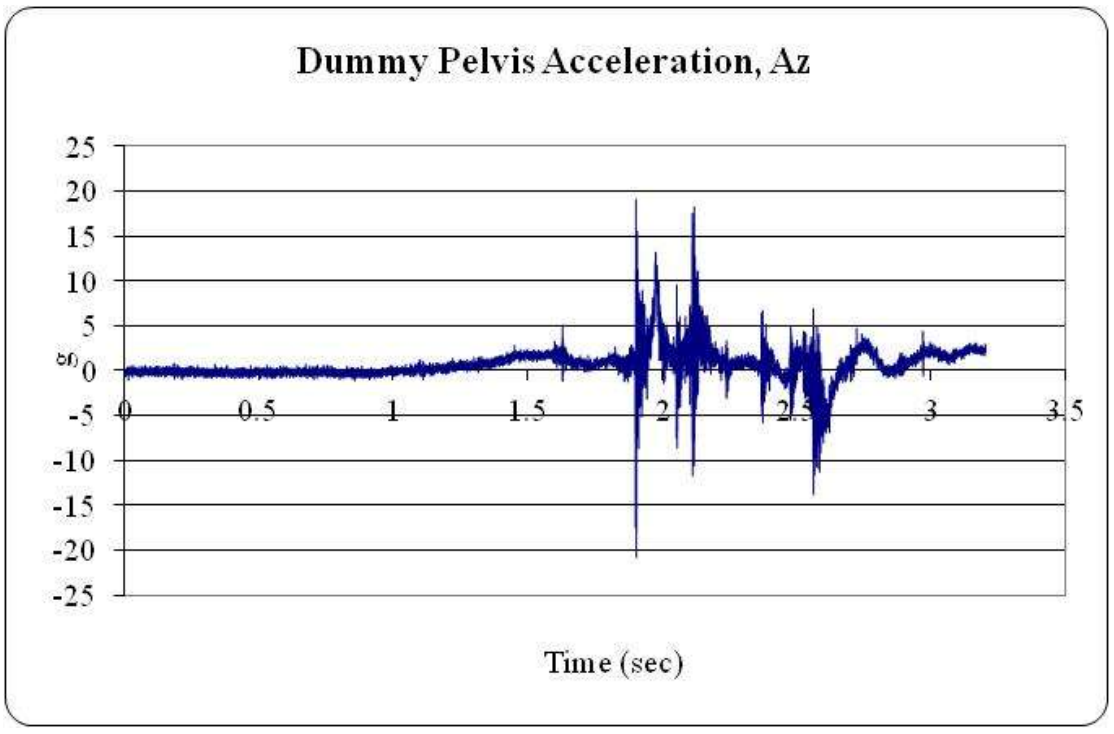
Data Sampling Rate: 10 kHz

Roll 2



Plot 51: Dummy Thorax Acceleration, Az vs. Time

Data Sampling Rate: 10 kHz



Plot 52: Dummy Pelvis Acceleration, Az vs. Time

Data Sampling Rate: 10 kHz

5. All Test Photographs – Test Setup

Test Setup


intercomp
E-Z WEIGH Scale
LF
RF
OVER
OVER
TOTAL:
50 lbs
50
OVER
LR
RR

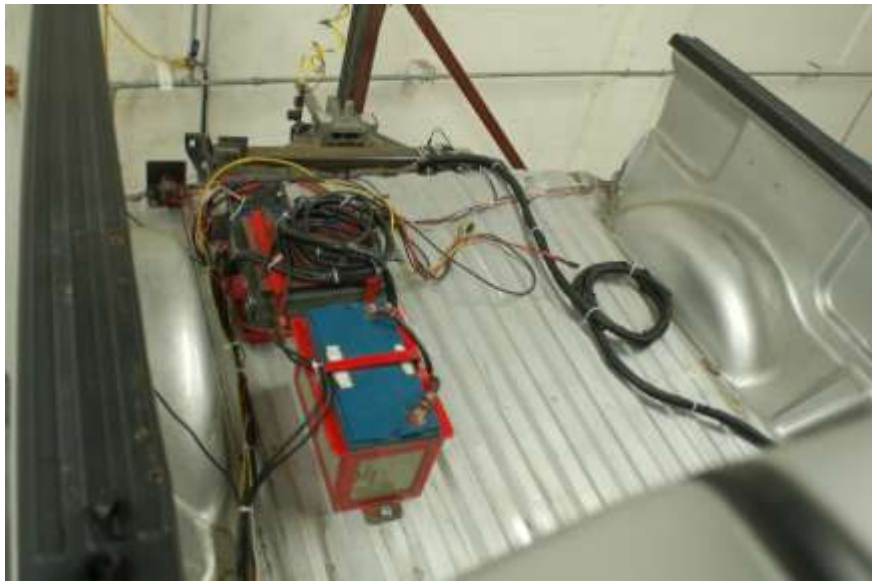
Vehicle Instrumentation

Vehicle Instrumentation

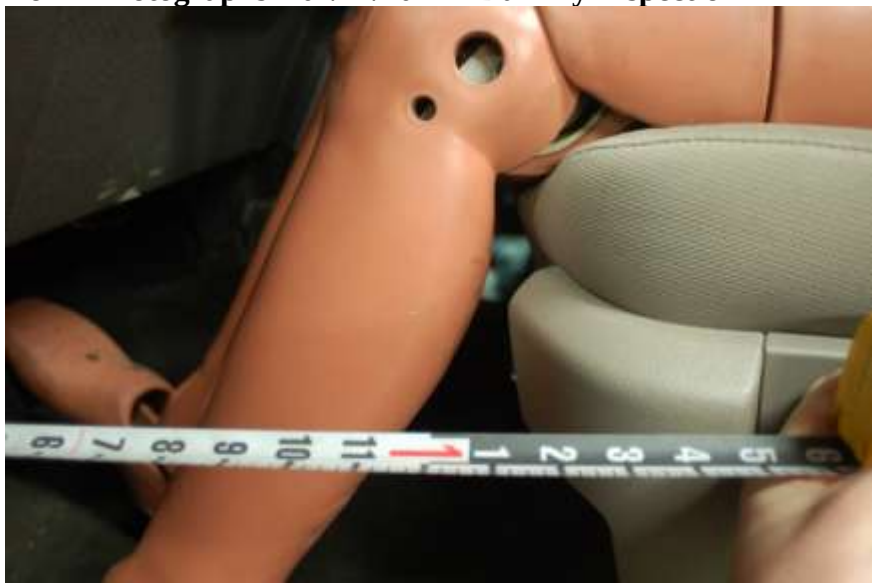



Vehicle Instrumentation



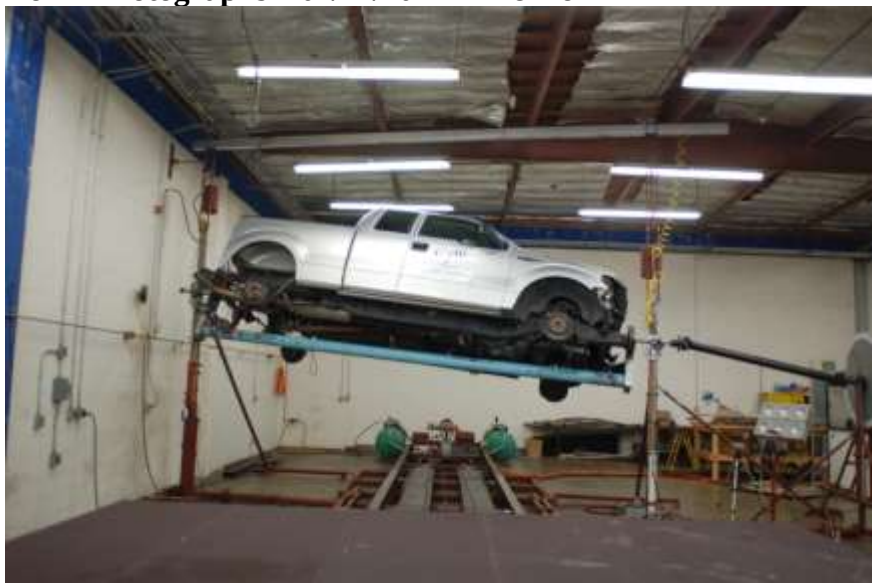



Roll 1 Photographs – 04/11/2012 – Dummy Inspection

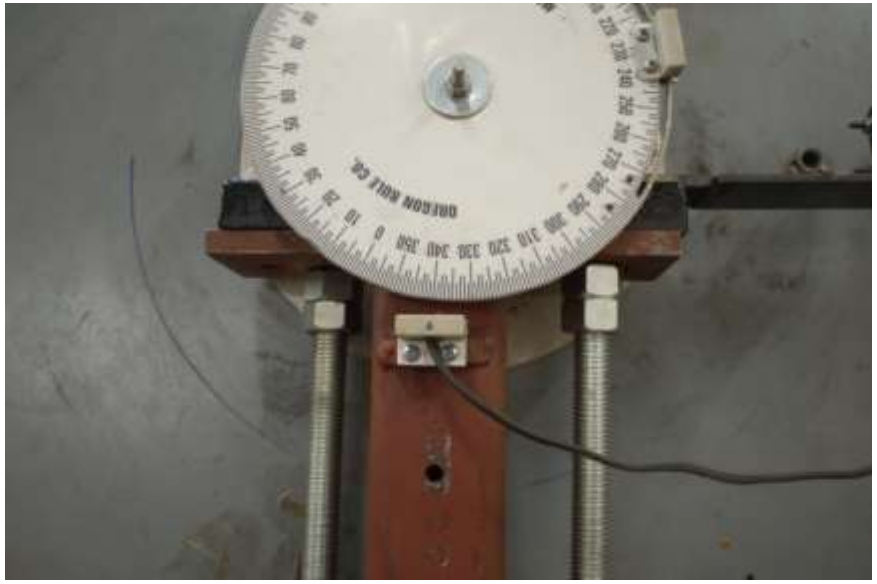


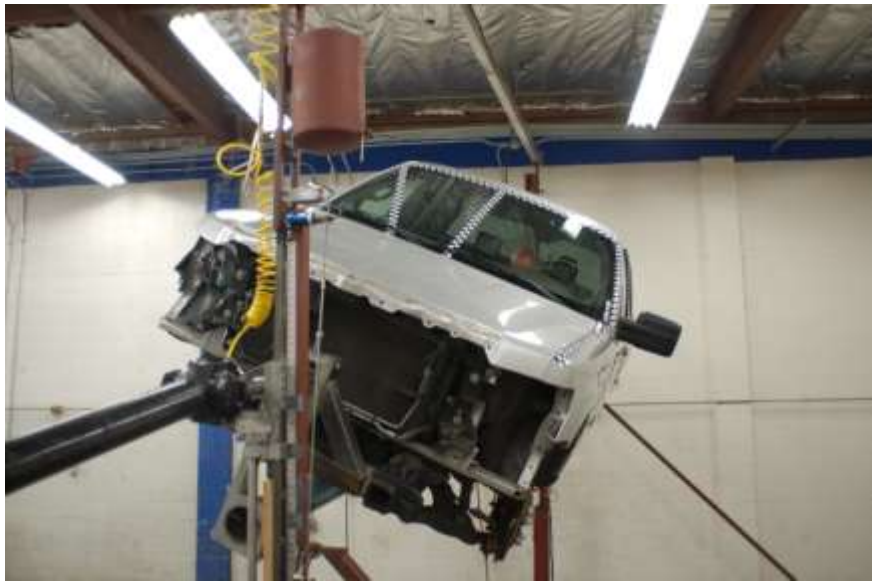
Roll 1 Photographs – 04/11/2012 – Dummy Inspection

Roll 1 Photographs – 04/11/2012 – Pre-Roll




Roll 1 Photographs – 04/11/2012 – Pre-Roll

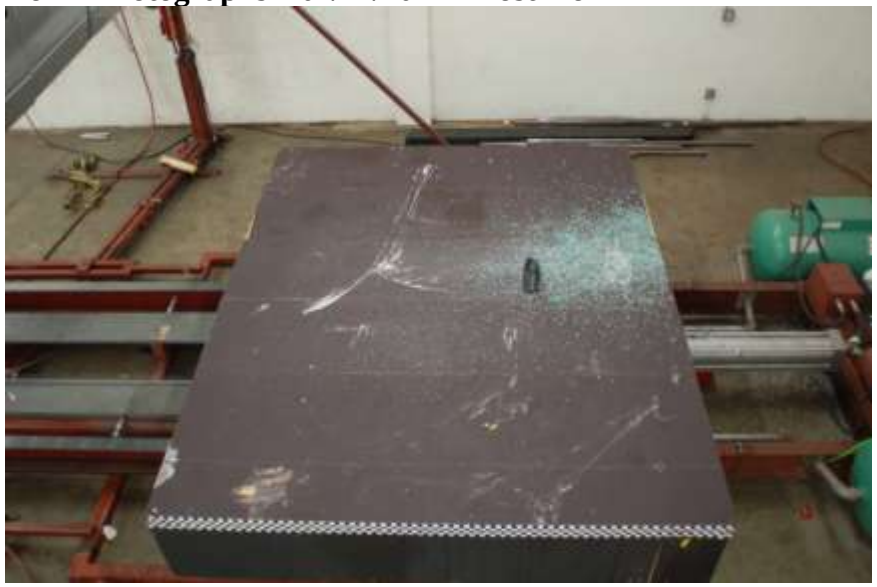
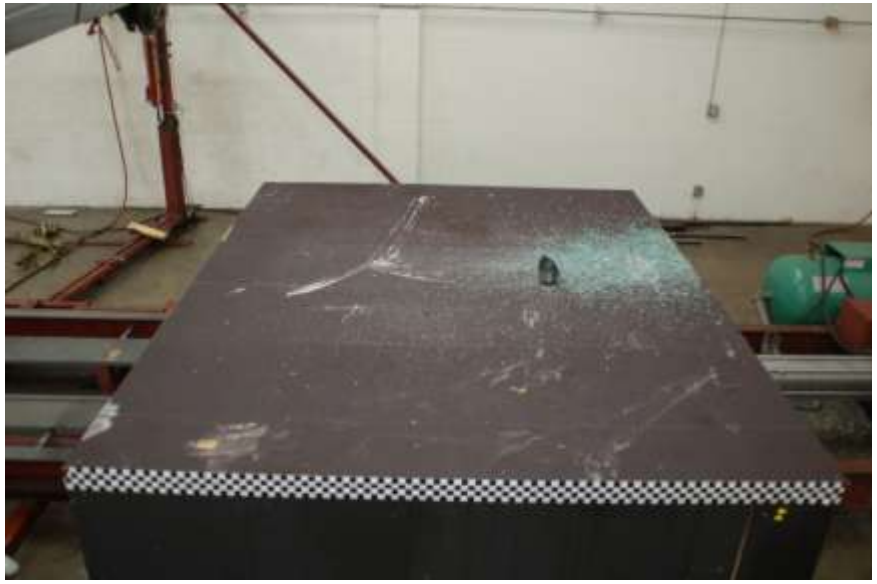




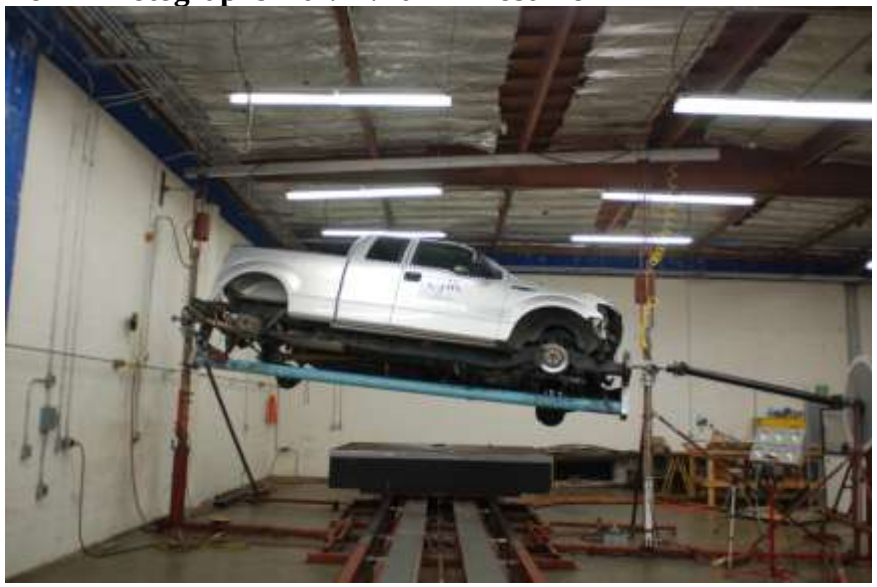
Roll 1 Photographs – 04/11/2012 – Pre-Roll

Roll 1 Photographs – 04/11/2012 – Pre-Roll

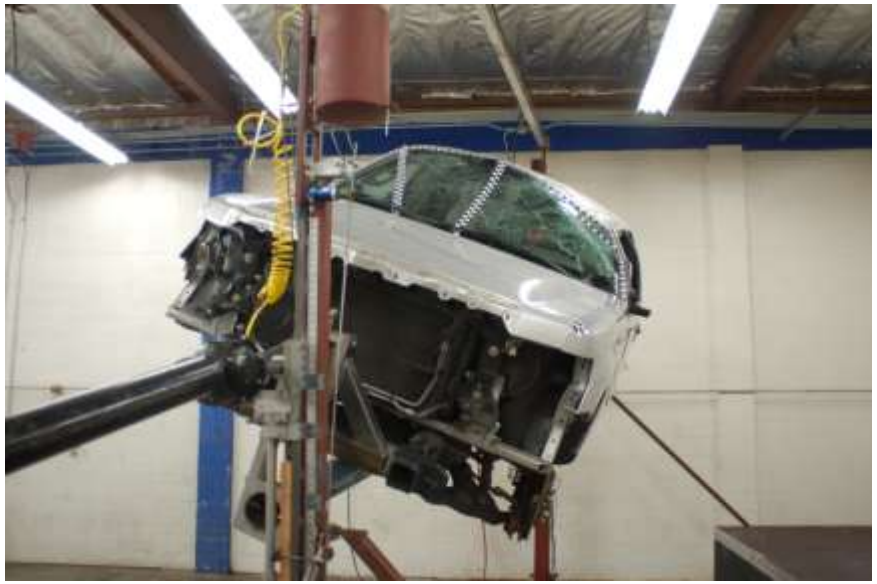
Roll 1 Photographs – 04/11/2012 – Post-Roll

Roll 1 Photographs – 04/11/2012 – Post-Roll

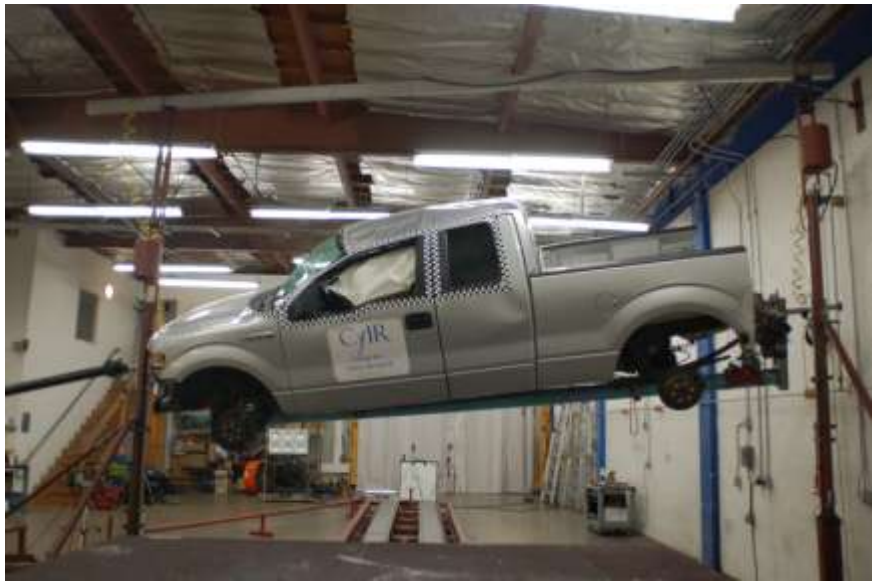



Roll 1 Photographs – 04/11/2012 – Post-Roll



Roll 1 Photographs – 04/11/2012 – Post-Roll



Roll 1 Photographs – 04/11/2012 – Post-Roll

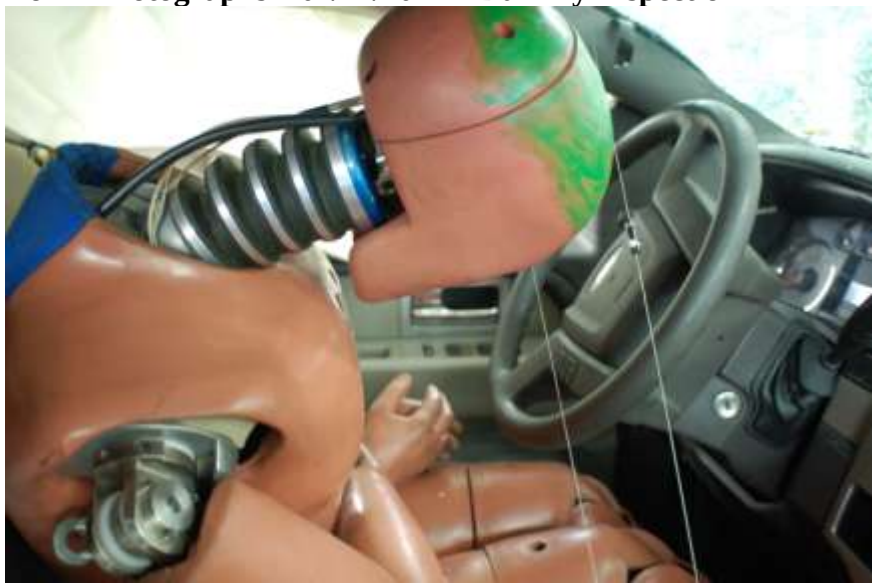
Roll 2 Photographs – 04/12/2012 – Dummy Inspection



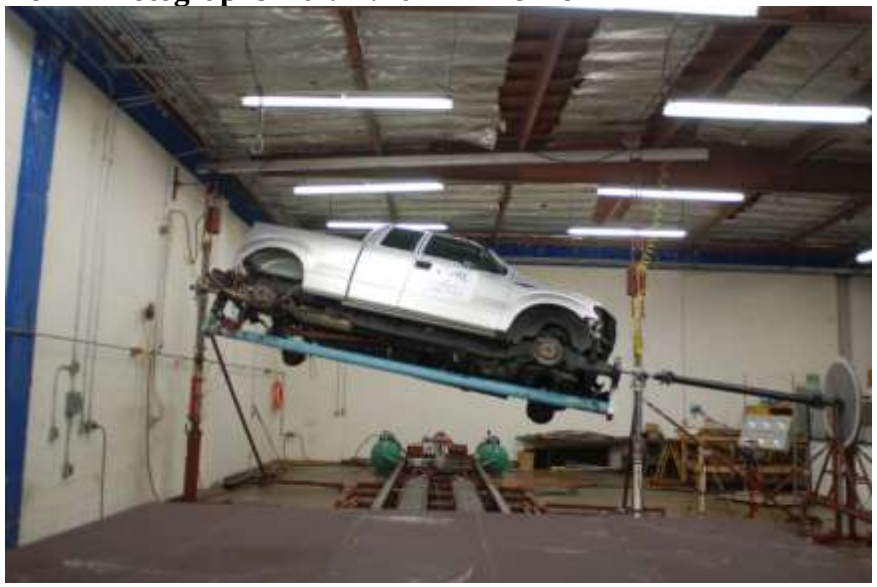

Roll 2 Photographs – 04/12/2012 – Dummy Inspection



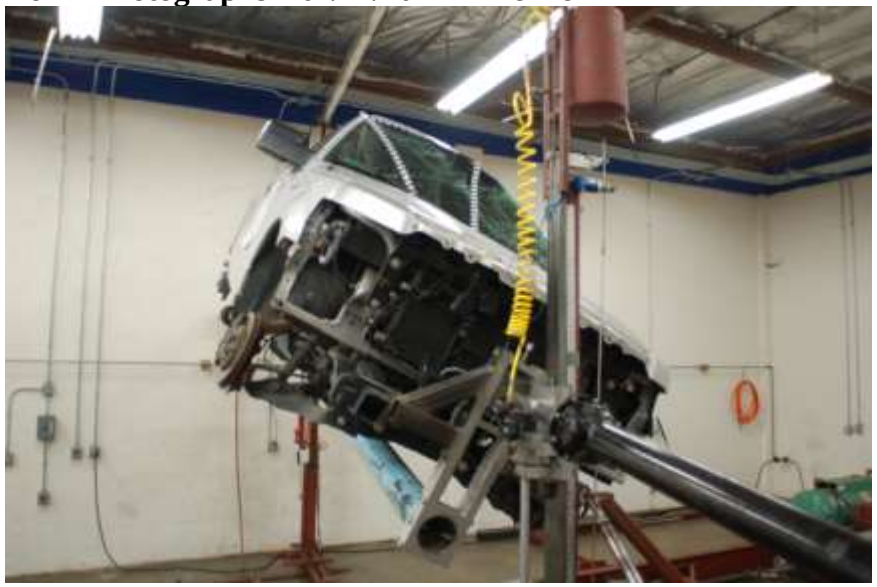

Roll 2 Photographs – 04/12/2012 – Dummy Inspection

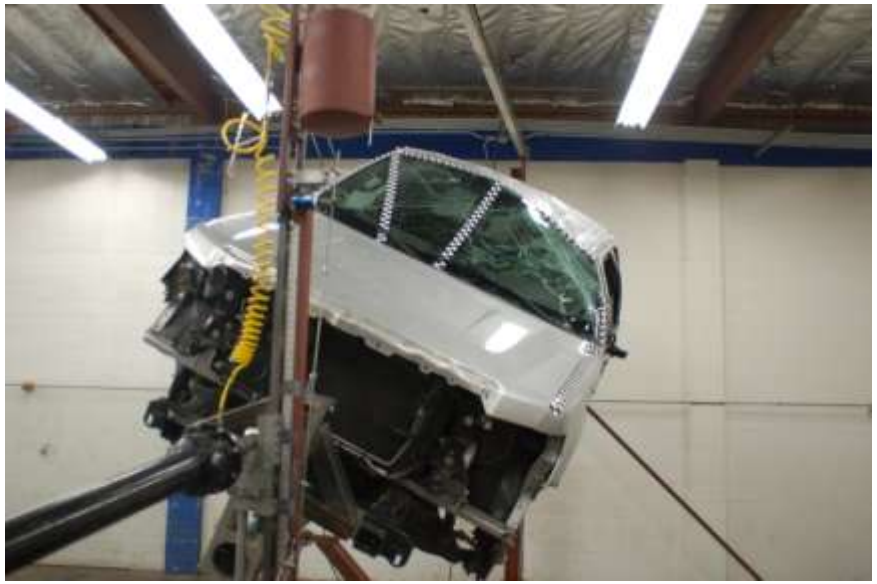


Roll 2 Photographs – 04/12/2012 – Pre-Roll




Roll 2 Photographs – 04/12/2012 – Pre-Roll

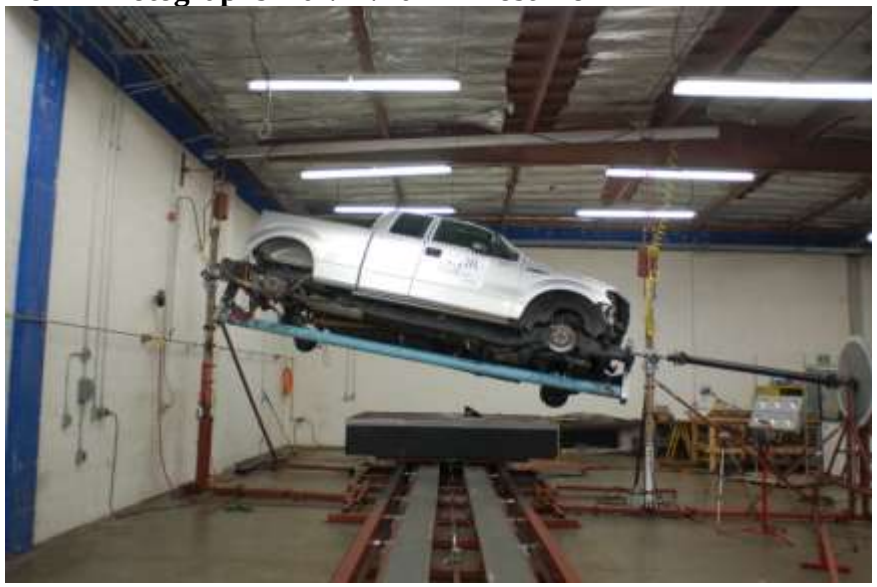




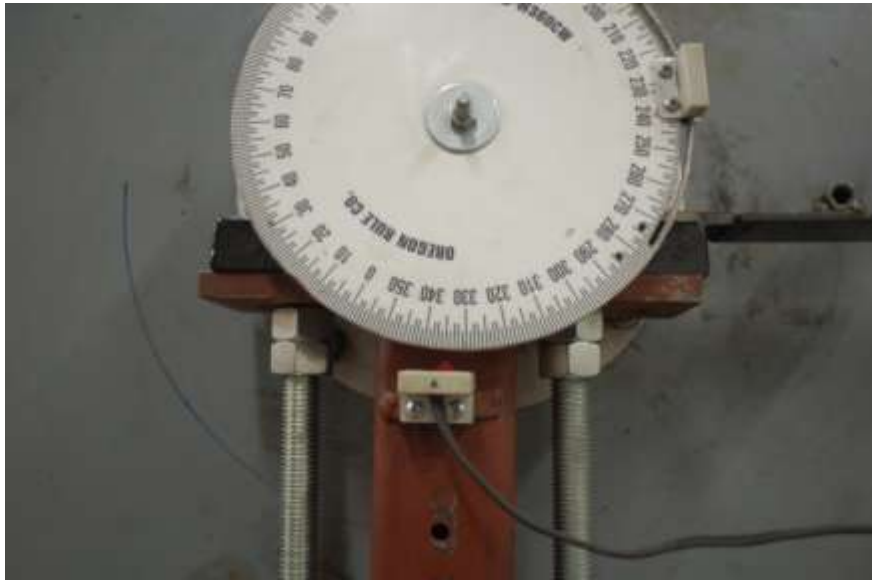
Roll 2 Photographs – 04/12/2012 – Pre-Roll

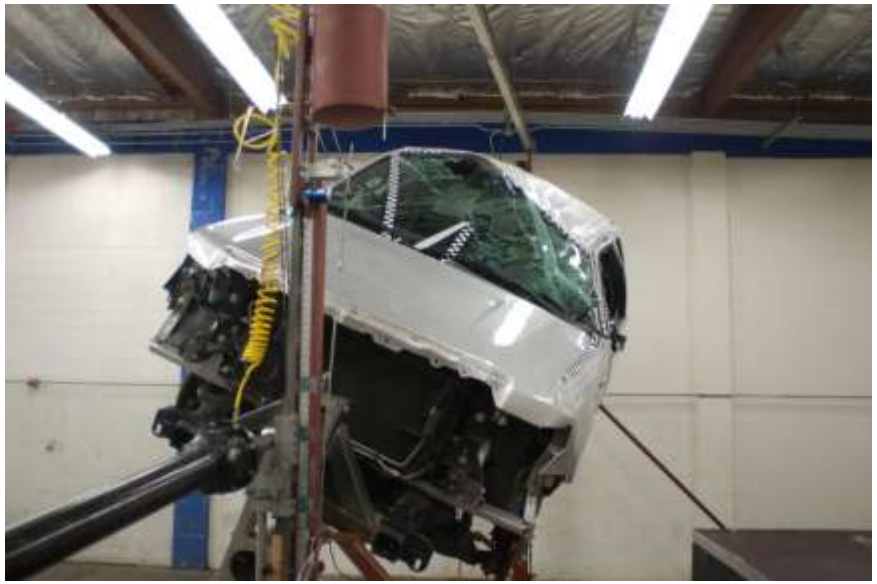
Roll 2 Photographs – 04/12/2012 – Pre-Roll

Roll 2 Photographs – 04/12/2012 – Post-Roll



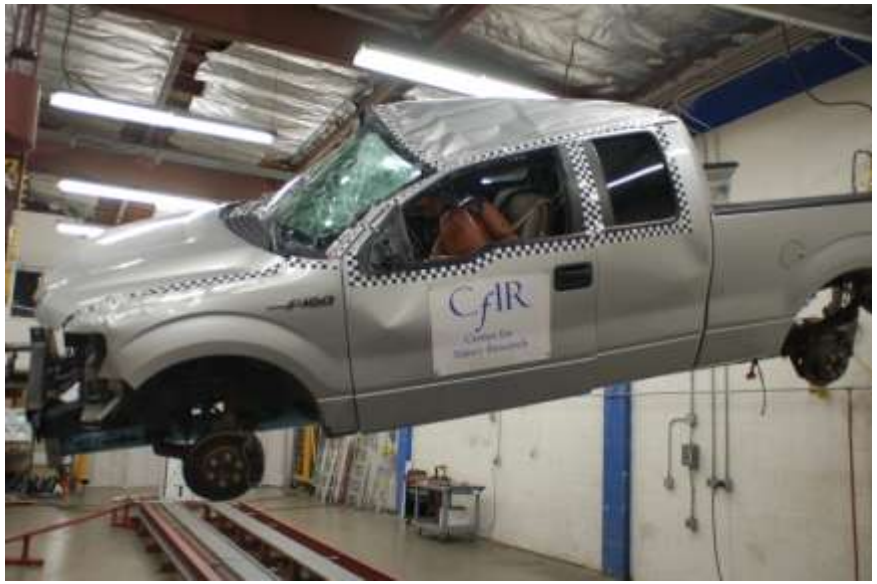

Roll 2 Photographs – 04/12/2012 – Post-Roll





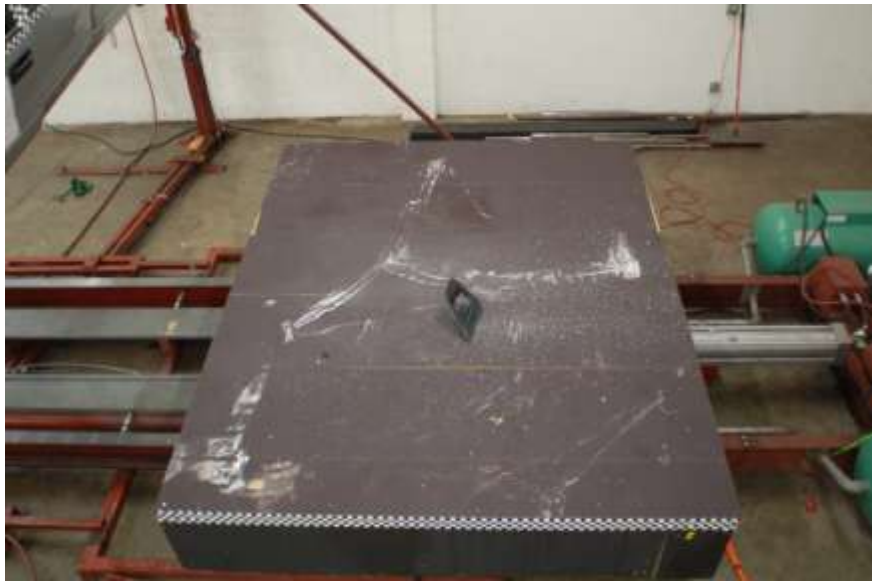
Roll 2 Photographs – 04/12/2012 – Post-Roll



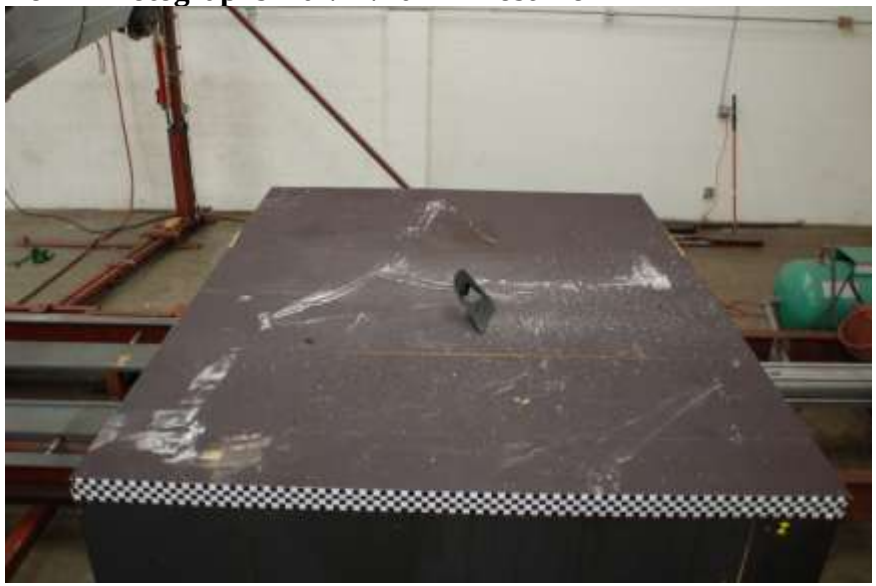



Roll 2 Photographs – 04/12/2012 – Post-Roll



Roll 2 Photographs – 04/12/2012 – Post-Roll



Pre-Test

Pre-Test

Pre-Test

Pre-Test

Pre-Test

Pre-Test